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THE PARIS EXHIBITION—HOTCHKISS ORDNANCE.

THERE can be little question that Messrs. Hotchkiss have supplied the most complete contribution to the Ordnance Department of the exhibition. Their guns are thoroughly well represented, the revolving pieces of 37, 47, 53, and 40 mm. being exhibited; also rapid fire guns of 37, 47, 57, 65, and 77 mm., and of 10 cm., light and heavy, also mountain and yacht guns of 42 mm., with ammunition. There is also a special torpedo (the Howell), with its apparatus. The general principles and the system of construction are, as far as possible, made uniform in all designs, with the object of simplifying matters to those who deal with the pieces on service in use or repair. On this subject Messrs. Hotchkiss write the following: It is to be remarked, in considering the development of calibers, that whatever may be the excellences developed in any system under application to a single caliber or a limited gradation of calibers, the measure of superiority of the system itself lies in the capability of its application without modification to the complete range of calibers within the scope of the class of artillery. If, for example, any given type of gun be adopted, and it be found necessary to modify the details of the breech mechanism or the type of mount as the calibers of the gun increase or diminish, the result is as unsatisfactory as if a different system were adopted with each caliber, and it is beyond doubt one of the first requirements of an efficient type of service artillery that throughout its calibers all its details should be similar. This being the case, it follows that the pieces admit of being illustrated by a comparatively few specimens, such as we have here selected.

We have especially taken the case of the 65 mm. or

FIG. 5

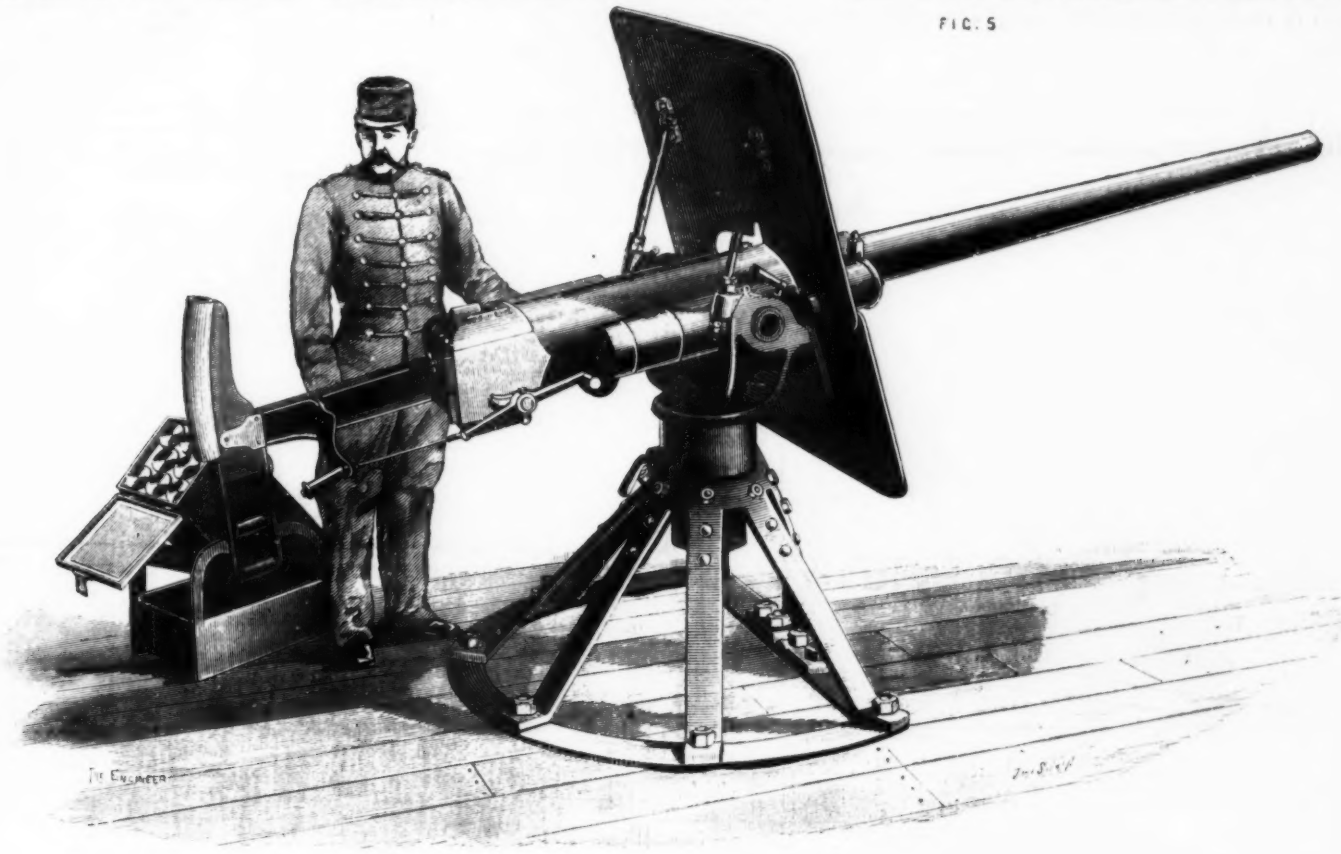
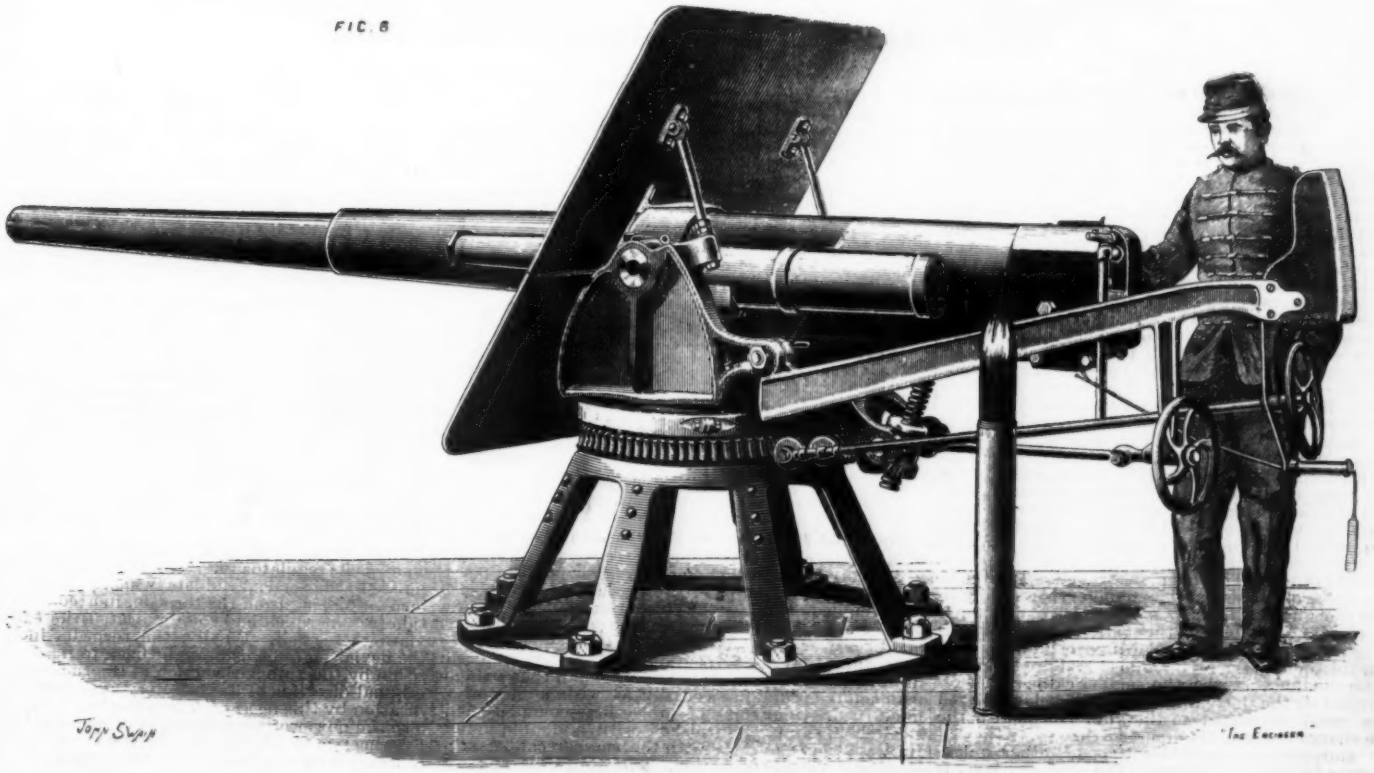


FIG. 6



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9 pounder, as being the most important. Of this gun, it is remarked that the general form and arrangement of parts corresponds to those of the smaller pieces. The weight of the gun is fixed at 150 times that of its projectile, giving thus more metal than is absolutely required for strength, but enabling two points of great advantage to be realized: (1) By a proper disposition it permits of greatly stiffening the long, slender, unsupported chase, thus securing a high degree of accuracy of fire; (2) the additional weight, while in no way affecting the mobility of the gun, appreciably reduces the firing strains on the mount and fastenings, which, with a light high-powered gun, are very severe even when a maximum length of recoil is permitted.

The weight of projectile was fixed at four times the weight of a cast iron ball of the same caliber, giving a slightly greater density of cross section than exists for the lighter calibers. As the general inclination at the time the designs were undertaken seemed in favor of an initial velocity of not less than 610 m. or 2,000 ft. per second, a length of bore and chamber were adopted giving 615 m. or 2,016 ft. muzzle velocity, with a maximum pressure of not over 2,500 kilogs. per square centimeter, or sixteen tons per square inch. The limit of effectiveness of black powder having been apparently reached in the 57 mm. caliber, it was determined to undertake the development of a class of brown powder suitable for the higher calibers, and a type of this powder manufactured at Sevran Livry, and called "C_2 brune," was provided. This powder proved on test to be thoroughly well suited to the gun. In form and size of grain, it corresponds exactly with the C_2 black powder used in the 47 mm. and 57 mm. guns. This

The interior of the body or tube is filled with bullets laid symmetrically and bedded in cast iron diaphragms shaped to fill up the cavities.

These are laid sufficiently loose, and are sufficiently weak to break up well. The bottom of the tube is closed with a steel disk. A common shell burst in a cell at Ochta broke into 147 pieces capable of killing; a steel shell, into thirty-four. The penetrative power of the steel projectiles of this gun was tested at Ochta, Russia; one blind shell passed through a front 4·5 in. wrought iron plate with 3 in. plates in rear, each at 13 in. interval from the plate in front of it; others fell a little short of this power. At 30 deg. projectiles passed through the first and second plates.

The rapid-firing gun of 65 mm.—2·57 in.—on recoil carriage and elastic support, presents the ordinary characteristics of the Hotchkiss gun of smaller caliber. For its employment on board ship, it is placed on a carriage of limited recoil and automatic recovery, similar to that of the pieces of 47 mm. and of 57 mm.; the pivot is placed in the socket of an elastic support; the cannon is thus at such a height above the bridge as to be easily maneuvered. The aiming and the firing of this gun, which is held against the shoulder, is performed with as much facility as with the lower calibers; the rapidity of fire is also about the same. The cartridges are arranged in metallic boxes containing eight rounds each; during the firing these boxes are placed on an inclined stand to facilitate the taking out of the ammunition. Besides common and steel shells and case shot, this gun fires a shrapnel furnished with a double action fuse; its caliber being sufficient to allow of the effectual employment of this projectile.

In general construction and breech mechanism it is similar to other Hotchkiss guns. As has been before noticed, it is claimed specially for the Hotchkiss system of construction that it is applicable without modification to the complete series of models of this species of gun within the limits that their caliber comes up to. The advantages of this uniformity are incontestable in war *materiel*, and it is to be observed that, with the rapid-firing Hotchkiss artillery, the three principal elements, breech mechanism, ammunition, and carriages, apply equally to all calibers from 37 mm.—1·46 in.—to 10 cm.—3·9 in. The carriage is similar to those of the smaller guns, except for the following modifications necessitated by the power and dimensions of the arm. The piece is roughly laid from the trail, but the elevation and accuracy of direction are obtained by means of wheels.

Guns of a caliber superior to 10 cm. are actually being designed. The adoption on service of smokeless powders, which at the same time will permit a considerable augmentation of velocity, will shortly increase to a remarkable degree the practical value of rapid-firing guns.

Principal Data.

Gun:		
Weight of gun		1,650 kg. or 3,637·6 lb.
Diameter of bore		100 mm.
Length of bore (42 calibers)		4·173 m.
Length of gun		4·413 m.
Ammunition:		
Common shell	Weight	15 kg. or 32 lb.
	Bursting charge	520 gr. or 1·15 lb.
Steel shell	Weight	15 kg. or 33 lb.
	Bursting charge	600 gr. or 1·32 lb.
Case shot	Weight	15 kg. or 33 lb.
	Number of balls	96

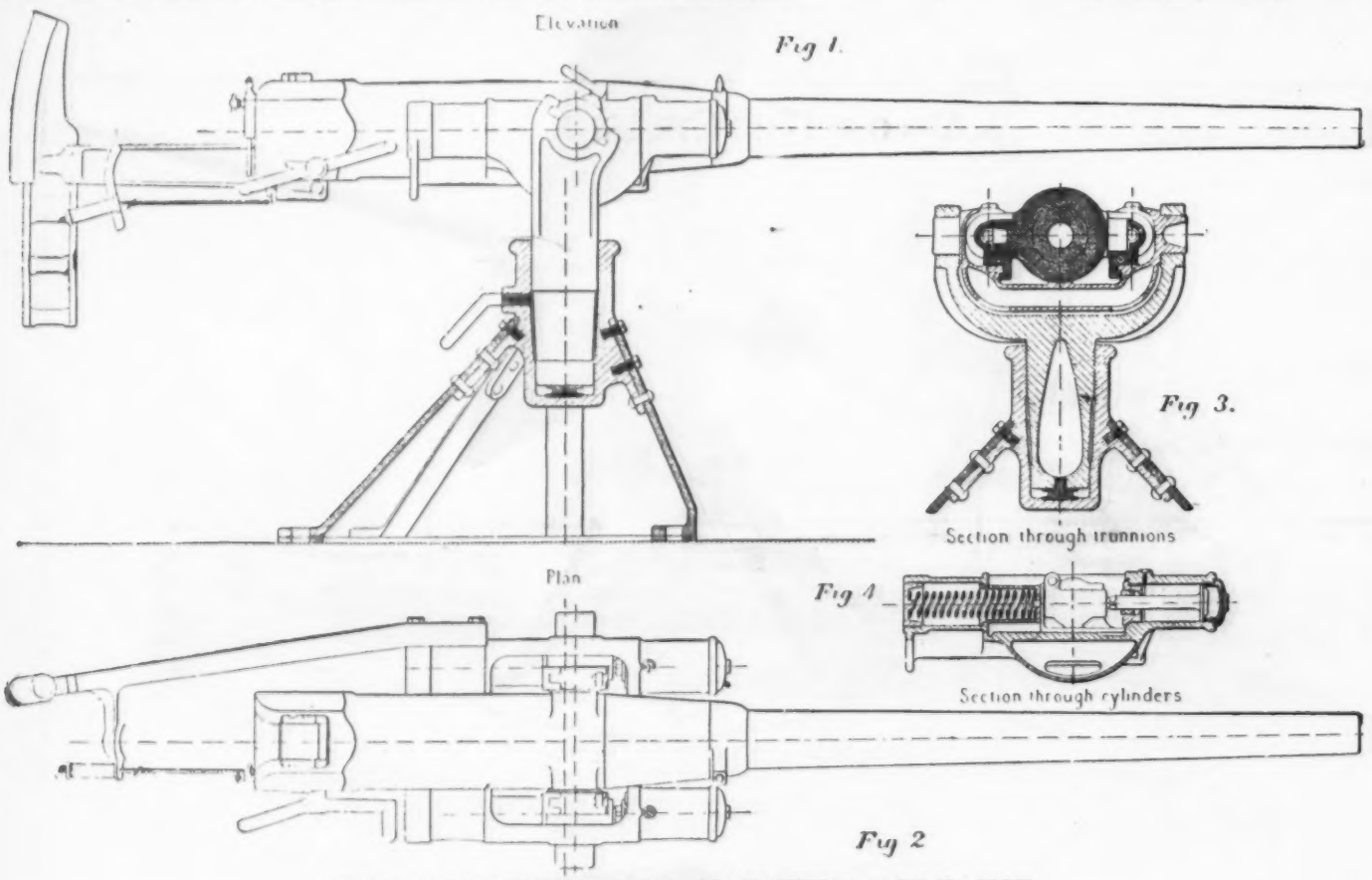

Fig 1.

Fig 3.

Fig 4

Fig 2

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piece is shown in elevation and plan in Figs. 1 and 2, and in section through the trunnions in Fig. 3, while the cylinder is shown in longitudinal section in Fig. 4, and the entire piece is given from a photograph in Fig. 5. The recoil mounting is of the same pattern as that used with the smaller calibers, and is arranged to guard entire the principle of aiming from the shoulder. A frame stand of the ordinary Hotchkiss pattern is the base; in this is mounted a pivot, which carries a cradle hung on trunnions. The gun itself is mounted in the cradle, its recoil of less than 5 in. being controlled by hydraulic cylinders in front of the trunnions, while springs in cylinders behind the trunnions force the gun out to the firing point. The shoulder piece does not touch the gun, but is bolted to the left cheek of the cradle—see Figs. 4 and 5. With the shoulder piece in place, the system exactly balances on the cradle trunnions. The oil capacity of the cylinders—see Fig. 4—is about 2¼ liters—2¼ quarts. A screw clamp at the pivot socket holds the gun in traversing, and another in the right cap square holds it in elevation. The pivot is arranged to carry a shield if required—see Fig. 5. An attachment to the shoulder piece permits of using the right hand, both in firing and aiming. This consists of a short cylinder projecting to the rear from the cartridge case shield, and forming a fixed handle. Within this slides another cylinder having a round projecting head. The firing lanyard from the sear is connected to the head of this movable cylinder. When aiming, the gunner seizes this handle to aid him in guiding the gun; at the moment of firing he simply draws his hand to the rear, this action partially withdrawing the inner cylinder and firing the gun.

With this mount the gun is aimed and fired directly from the shoulder, as with the smaller calibers, the recoil strains on the fastenings and deck being relieved by the recoil permitted to the gun, which with the service charge is about 114 mm.—4·5 in.

The ammunition resembles that of other quick-firing guns in general features. The shrapnel body is of steel tube, weakened by longitudinal grooves, with a cast iron head containing the magazine and tissue fuse.

Principal Data.

Gun:		
Weight of gun		600 kg. or 1,323 lb.
Diameter of bore		65 mm. or 2·57 in.
Length of bore (43 calibers)		2·793 m. or 7·49 ft.
Length of gun		3·025 m. or 9·92 ft.
Ammunition:		
Common shell	Weight	4 kg. or 8·8 lb.
	Bursting charge	112 gr. or 1.738 gr.
Steel shell	Weight	4 kg. or 8·8 lb.
	Bursting charge	145 gr. or 2,238 grs.
Case shot	Weight	4 kg. or 8 8 lb.
	Number of balls	169
Shrapnel	Weight	4 kg. or 8·8 lb.
	Total No. of fragments	135
	Bursting charge	55 gr. or 849 grs.
Ammunition:—		
Charge	Common shell and steel shell	1,650 gr. or 3·64 lb.
	Shrapnel and case shot	1,450 gr. or 3·20 lb.
Initial velocity of the shell		620 m. or 2 034 ft.
Total weight of cartridge	with shell	7·150 kg. or 15·76 lb.
	with shrapnel and case	6·950 kg. or 15·32 lb.
Total length of cartridge		668 mm. or 26·3 in.
Carriage:		
Weight of carriage without shield		750 kg. or 1,653 lb.
Greatest angles of fire	in elevation	+ 15 deg.
		— 15 deg.
	in direction	360 deg.
Total weight of gun and carriage		1,350 kg. or 2,976 lb.
Number of rounds per minute		20 rounds.
Thickness of the plate perforated by the steel shell		16 cm.

The rapid-firing gun of 10 cm.—3·9 in.—on carriage of limited recoil and automatic recovery with central pivot, may be classed among the guns capable of piercing the armor of ships; its projectile of 15 kilogs.—33 lb.—weight possesses sufficient power to pierce a plate of 20 cm.—7·9 in.—thickness. The advantages that it possesses over the ordinary guns actually in service are manifest, taking into account the fact that it can fire ten to twelve rounds per minute, and that a single man can point and fire as easily as with a gun of 57 mm. It fires four sorts of projectiles—common shell, steel shell, shrapnel furnished with a double action fuse, and case shot. As with the smaller calibers, the loading is a single operation. The projectile and the powder charge are united in a metallic case, which, on an average, can be recharged from six to eight times.

Shrapnel	Weight	15 kg. or 33 lb.
	Bursting charge	150 gr.
	Number of fragments	350.
Charge for	Common and steel shell	6 kg. or 13·3 lb.
	Case and shrapnel	5 kg. or 11·0 lb.
Initial velocity of shell		600 m. or 1,969 ft.
Total weight of cartridge (shell)		25·300 kg. or 55 8 lb.
Total length of cartridge		1,004 mm. or 4·18 in.
Carriage:		
Weight of carriage without shield		1,350 kg. or 2,976 lb.
Weight of shield and gear		250 kg. or 551 lb.
Thickness of shield		16 mm. or 0·629 in.
Maximum angles of fire	in elevation	+ 12 deg.
		— 8 deg.
	in direction	360 deg.
Weight of gun and its carriage		3,430 kg. or 7,562 lb.

The Howell automatic torpedo was illustrated and described in *The Engineer* for August 17, 1888. It claims, owing to the gyroscopic principle on which its mode of propulsion is based, that it maintains its initial direction in a manner absolutely automatic. As soon as it is launched, it takes automatically, by means of another special mechanism, the depth for which it is regulated, and then moves in a vertical plane. In a horizontal plane its course is straight, and independent of the action of deviating forces. Under the action of exterior transverse forces it is claimed that it simply inclines to one side or the other, instead of changing its direction to left or right, like similar engines at present known.

The inclination given to the torpedo by these forces compels its regulator to give a succession of light impulses to the vertical rudders, which produces a movement, resulting from the torpedo, in a contrary direction to that which had communicated the exterior deviating force to it. Finally, the torpedo, inclined by the deviating force, is brought back to its normal position by the automatic action of the rudders, and the original direction of its trajectory experiences no modification by this means. The directing force, which is also the power of propulsion, is stored up in a steel fly-wheel, to which has been imparted great swiftness of rotation by means of a suitable machine fixed in the launching tube. The stored-up work in the fly-wheel is then directly transmitted to two propelling screws.

The gyroscopic wheel gives to the torpedo its mechanical force of direction. It is claimed for it that it stores up at the same time more power of propulsion in a smaller space and under a less weight than would be supplied by any other really practical mode. The wheel revolves with the aid of a "moteur" set in motion by steam, electricity, compressed air, etc., according to the special exigences of the service. The necessary swiftness of rotation can be produced in about two or three minutes; it is then easily maintained until the moment of the launching of the torpedo.

The mechanism of the torpedo is exceedingly simple. It comprehends: The gyroscopic wheel, its axis, and other pieces; the two propellers, united to the wheel by a gearing; the automatic regulator of immersion and direction; the horizontal and vertical screws. The body of the torpedo is of manganese bronze; all the other parts are of phosphor bronze, with the exception of the wheel and the screw shafts, which are of steel. The explosive charge is heavier than that of other torpedoes of the same displacement. For practice firing the torpedo is so arranged that it will stop at any point of its line and reascend to the surface. It can only be made to run to the end of its course, or float with the percussion lock disarmed. The torpedo is always ready to be launched without the necessity of a new adjustment. It requires no other preparation than the opening of the valve to put in motion the auxiliary, "moteur," which communicates to the wheel the necessary rotary movement. It is then immediately ready for use. The wheels perform about 10,000 revolutions per minute. In the same time the screws only revolve 5,000 times.

The Howell torpedo is relatively short; it is consequently easy to lodge it and to maneuver it on board. A torpedo of 9 ft. (2.890 m.) and 14 in. (356 mm.) is shown in the exhibition. Length (9 ft.), 2·890 m.; diameter (14 in.), 356 mm.; weight (132 lb.), 60 kg.; weight of wheel (463·0 lb.), 210 kg.; weight of bursting charge 110·2 lb.), 50 kg.; average speed over a course of 400 m., 28 knots.

The Howell torpedo can be fired with any sort of launching apparatus which possesses an auxiliary "moteur" capable of giving to the wheel the necessary rotation. It can be fired indifferently from the fore part or the sides of the ship. Beyond the addition of the "moteur" in question, the tubes actually employed for the launching of the Whitehead and Schwarzkopf torpedoes only require very slight modifications in order to fire the Howell topedo. The Hotchkiss Company manufactures the launching apparatus and necessary accessories to the employment of the latter. The launching apparatus can be arranged to fire the torpedo with compressed air or with an explosive firing charge.—*The Engineer.*

THE 2,000 TON CRUISERS.

WE publish an engraving of the 2,000 ton steel cruisers, now known as cruisers Nos. 9, 10, and 11, which were authorized by an act of Congress approved Sept. 7, 1888, the limit of cost being $700,000 each. The principal dimensions are as follows: Length on load water line 257 feet; breadth, extreme, 37 feet; depth of hold to under side of spar deck plank amidship, 19 feet 6 inches; draught of water, mean normal, 14 feet 6 inches; displacement in tons to load water line, 2,000; tons per inch at load water line, 15¼; area of immersed midship section, 665 square feet; transverse meta-center above center of gravity, 7 feet; to alter trim 1 inch, 200 foot tons; indicated horse power (forced draught), 5,400; maximum speed per hour, 18 knots in smooth water; complement officers and crew, 185.

They are twin-screw protected cruisers with poop and forecastle decks, with open gun deck between, fitted with a water-tight deck of 17/8 pounds plating at side, reduced to 12 pounds in center, extending the entire length of the vessel, this deck being below the load water line at the side 30 inches. Below this deck are placed the machinery, magazines, and steering arrangements.

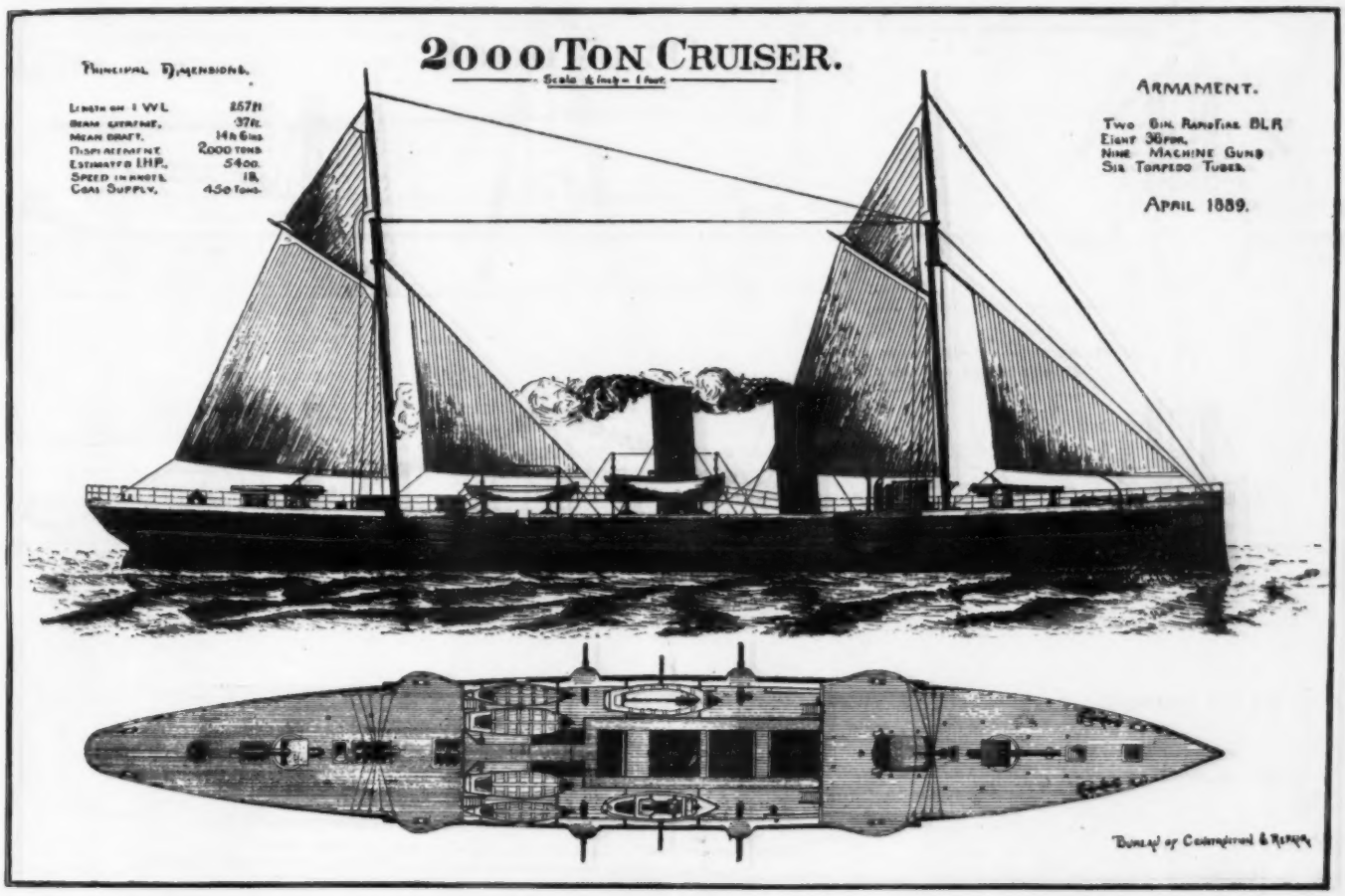
Among the improvements in these vessels is an increase of speed, rearrangement of battery, which is to be composed entirely of rapid fire guns, and a coffer dam protection extending throughout the entire machinery space. The berthing accommodation and officers' quarters have been greatly improved, quite an innovation on previous arrangements having been made in the location of steerage, which is aft of the wardroom, giving the senior officers quarters nearer amidships, which is freer from the jar of machinery and motion of the ship; the entrance to the steerage is effected through the after 6 inch gun supports, which leaves an exclusive entrance to the wardroom for the officers quartered there and at the same time giving spacious and more retired accommodations to the steerage. The main battery is composed of two 6 inch rapid fire B. L. R. and eight 4 inch rapid fire B. L. R. The secondary battery consists of two 6 pounders, two 3 pounders, two revolving cannons, and one Gatling gun.

The torpedo outfit of these vessels will be six torpedo guns or launching torpedoes, fixed one in the stem and stern, and training tubes on the sides. Auto-mobile torpedoes will be fired from these tubes, and there will be a complete outfit of boat spar torpedo gear and charges; a conning tower, oval in shape, is located on the forecastle deck, being 7½ feet athwartships by 4 feet fore and aft, and 5 feet 4½ inches above the deck.

The tower is fitted complete with steam steering wheel, engine room telegraphs, and speaking tubes. A wood pilot or chart house is fitted forward of the conning tower, having plate glass windows, steam steering wheel, engine room telegraphs, tell-tale for rudder, chart table, etc.

The rig is that of a two-masted schooner having a small spread of canvas. The normal coal supply is 200 tons, but the bunker capacity is 435 tons. This coal is disposed in wake of the machinery and boilers, so as to give the greatest protection. There will be an installation of electric light on board. Means are provided for securing natural and artificial ventilation in the living and storage spaces, utilizing frame spaces, together with louvers and cowls fitted along the top, sides, and such ducts as are necessary to effect communication with the spaces below. Automatic valves are fitted in ventilating pipes where they pass through water-tight bulkheads to prevent the flood of water from one compartment to another. Escape for the explosive gases generated in the bunkers is provided for by means of inlet and outlet pipes, and trunks leading to the funnel castings.

There is a complete steam pumping arrangement fitted to be used for bilge drainage or fire purposes; also, 7½ inch and 5½ inch hand pumps for draining the water-tight compartments, engine and shaft bearers, platforms, etc., delivering overboard or into the fire main. The fire main is worked nearly the whole length of the ship and can be charged with water at a high pressure from the steam pumps, being also connected with hand pumps, and fitted with the necessary nozzles and hose. The motive power for the twin screws is furnished by two triple expansion engines of 5,400 horse power, with cylinders of 20½, 39, and 63 inches diameter, and a stroke of 33 inches. The engines and boilers are placed in separate water-tight compartments. There will be independent air and circulating pumps, and auxiliary condensers and pumps for auxiliary machinery. The crank shafts are made interchangeable. All framing, bed plates, pistons, etc., are of cast steel, with working parts of best forged steel. The boilers are of steel, designed for a working pressure of 160 pounds, and are five in number, of the return fire tubular type. Three of them are double-ended and two single-ended. The latter are to be used as auxiliaries, but, when steaming full power, can be connected with the main engines.—*Army and Navy Register.*



THE NEW 2,000 TON CRUISERS, AUTHORIZED BY CONGRESS SEPTEMBER 7, 1888.

COALING OF WAR SHIPS.

A PAPER on this subject was read not long ago by Lieut. T. Y. Greet, R.N., before the United Service Institution, and is given in the *Journal*, from which we make the following abstracts:

The coaling arrangements of the fleet, the most important factor in the whole science of naval warfare, appears to have been lost sight of in the great and certainly very important items of speed armor, and guns. Yet what will be the use of these, if the ship cannot move for want of the means of propulsion?

The following are some of the times taken in coaling:

Agincourt, at Plymouth, with a large lighter on each side, fitted with derricks and steam winches and every facility, owing to her numerous ports	500 tons.	12 hours.
Iron Duke, at Plymouth, with one lighter, but having only one hatch, consequently only able to coal in one position...	330 tons.	23 hours.
Iron Duke, at Portsmouth, a jetty on one side, and a lighter on the other, bags being already filled...	55 "	2½ "

The following gives some idea of what is at present considered smart work in coaling: One commander signals to another, "375 tons in 19 hours, what do you think of it?" Yet considering that ships carry 1,000 tons as a rule, this would mean a ship being out of action for nearly three days; and one has to consider what would be the result to the men. They come away from a blockade harassed and worn out by the anxiety of night and day lookout and constant attack by torpedo boats, to have three days of utter discomfort and extreme hard work, which I venture to say would swell the sick list to an alarming extent, and so tend to cripple the fighting capabilities of the ship, as every man is a fighting factor.

Now, from the foregoing, it is evident that what is required is that a ship should be able to take in her coal on her station in the blockade, and at a very quick rate; also that she should constantly replenish, and so be ready for any contingency.

It seems strange that the coaling arrangements at present are practically the same as they were when steam was first introduced into the navy.

At Portland, the bags are first filled at the coal wharf by men from the ship coaling, they are got into lighters fitted with no appliances, and then hoisted on board. This is a very tedious process.

At Portsmouth, the coal bags are generally ready

filled at the wharf, and the lighters also are loaded with them, whence they are hoisted in by the ship's appliances.

With regard to coaling at sea, under the same conditions of wind and weather, it would certainly have the same advantages over the present system there as it would have in port.

I think it hardly necessary to discuss the way in which the coaling is done on board a man-of-war. But suffice it to say, it is done by whips from yards, stays, or derricks rigged over the ports, manual labor and steam capstan being the power employed.

The author advocates the employment of special boats for coaling, of which he gives a drawing, which we reproduce.

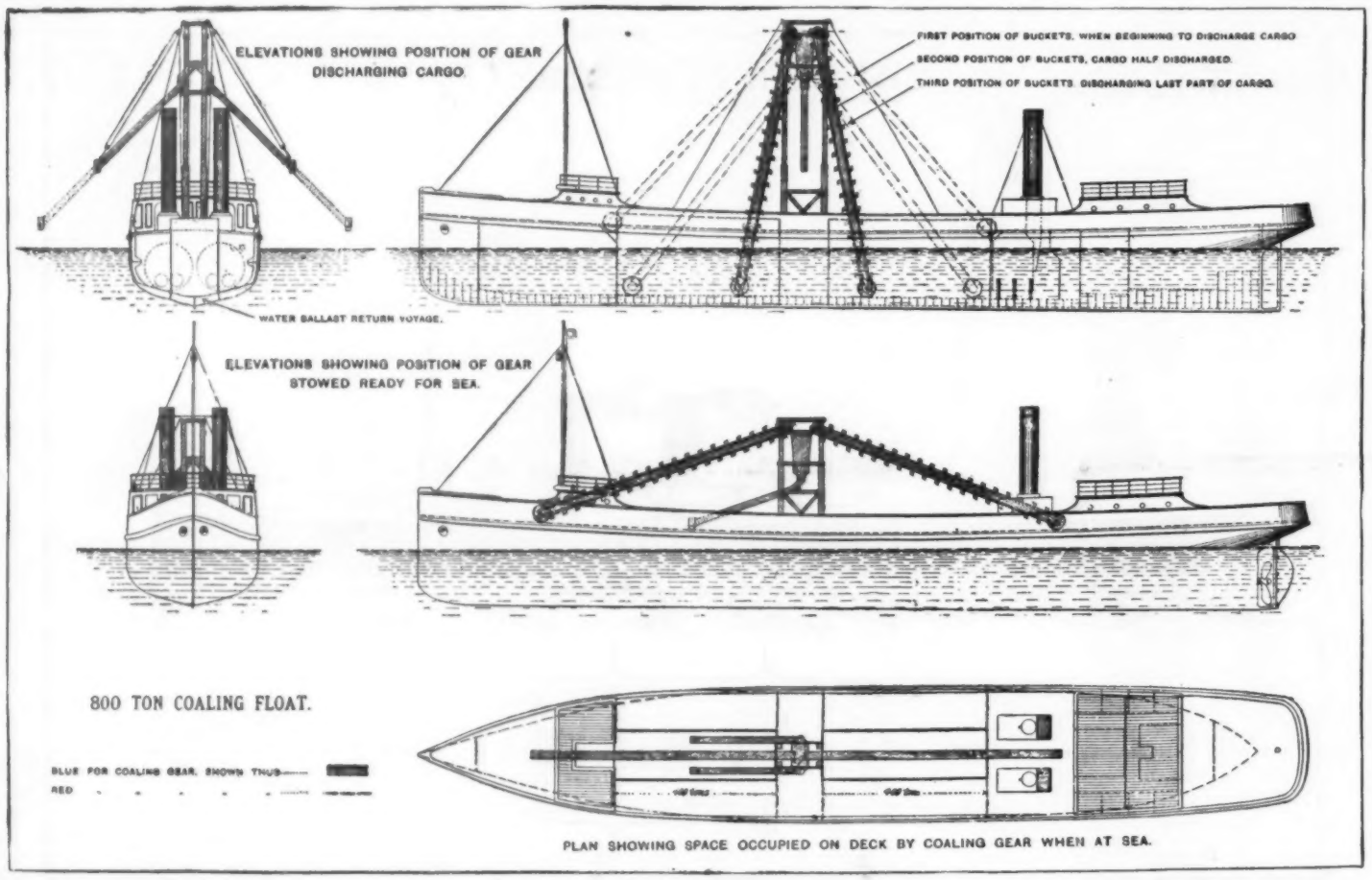
The following is a description of the vessel and her appliances:

The collier can be of any size, and fitted out as a seagoing vessel, with engines of sufficient power to insure a good speed.

The coaling apparatus is worked by steam supplied from the main boilers; this is important, because no donkey or auxiliary boilers are required. The exhaust steam from the coaling machinery is carried back to main condensers in engine room, thus keeping the water in main boilers in good condition, as no waste is required to be made up by sea water feed.

The coal is delivered on board the ship through telescopic iron tubes or shoots, direct into portable funnels; or the spout on the end of shoot is placed directly into the bunker hole in the deck, and the delivery is regulated by the speed of coaling machinery, and may be from 20 to 200 tons per hour, as found most convenient.

The holds are ceiled at sides and bottom with light


ELEVATIONS SHOWING POSITION OF GEAR DISCHARGING CARGO.
FIRST POSITION OF BUCKETS, WHEN BEGINNING TO DISCHARGE CARGO.
SECOND POSITION OF BUCKETS, CARGO HALF DISCHARGED.
THIRD POSITION OF BUCKETS, DISCHARGING LAST PART OF CARGO.
WATER BALLAST RETURN VOYAGE.
ELEVATIONS SHOWING POSITION OF GEAR STOWED READY FOR SEA.
800 TON COALING FLOAT.
BLUE FOR COALING GEAR, SHOWN THUS
RED
PLAN SHOWING SPACE OCCUPIED ON DECK BY COALING GEAR WHEN AT SEA.

plating to secure a smooth surface and facilitate the flow of coal to lower ends of booms.

The collier is fitted with six bulkheads. The machinery for working the cargo is fixed between the two midship bulkheads, and consists of one pair of small engines to work the coal buckets, and another pair to lift and lower the hopper and coal shoots.

Heavy wood rubbing pieces are attached on the sides and gunwale.

The forward part below deck is conveniently fitted up for berthing the crew, the after part below deck with cabins, etc., for officers. The lavatories are placed under the bridge deck forward.

When, in special cases of build, ballast is required, the ceiling in bottom of holds is made thicker, the space between ceiling and bottom forming a very convenient water ballast chamber.

The price is of course dependent on the requirement and capacity, the larger the collier, the less cost per ton.

The coaling of steamships is by this method performed very quickly, at minimum of labor and dust.

On account of the sponson ports and overhanging gear on a man-of-war's sides, the collier should carry very large fenders of about six feet in diameter; there would then be little chance of damage being done to either collier or war ship. These fenders could easily be made of a suitable material, giving lightness and elasticity, for instance, coir rope.

An exact position with regard to lying alongside is not necessary, as the end of the coal shoot is quickly guyed to any particular bunker hole where the coal is required. This is a very important feature, as it gives the men time to carefully trim the bunkers, and not interfere with the steady delivery of coal.

The coal is delivered into the telescopic shoot from a hopper supplied by buckets, each of one hundredweight or other suitable capacity, attached to steel endless chains, working on barrels on the ends of a light steel-plated boom. The upper ends of booms are hinged on the barrel shaft working in bearings secured to the hopper. The hopper is guided vertically by the light plated steel columns, and lifted or lowered by screws attached to under side of hopper, worked by suitable machinery placed in the center compartment under deck. The elevation of the hopper is decided by the position and level of coal in the holds. The two operations, viz., elevating coal to the hopper and lifting or lowering the hopper with coal shoots attached, are quite independent of each other and simultaneous, and manipulated from the same locality; when the last part of the cargo is being delivered, the hopper is at its lowest position, with the lower ends of bucket booms at the farthest ends of the holds. At the commencement of discharging cargo, the traveler wheels on lower end of booms are resting on the surface of the coal. As the cargo is being discharged, the booms gradually radiate to the position tinted blue, the traveler wheels resting on the bottom ceiling plating, then by lowering the hopper the ends of the booms travel to the extreme limits of the holds. The operations of elevating the coal to the hopper, of lowering or lifting the hopper with coal shoots are entirely in the hands of the engineer, and made at intervals or continuous, as may be convenient.

When making the voyage, the apparatus is lowered to the position shown, the light steel-plated columns being telescopic, the coal shoots are turned fore and aft, the whole occupying the small central deck space shown on plan. The whole apparatus then offers very little surface to the wind.

When bunker holes are inaccessible to ends of coal shoots, the delivery is directed in portable tubes or trolleys, and tipped at a convenient bunker hole. These trolleys form part of the collier's gear, are made light, and readily lifted on board. The portable funnels before mentioned are also part of her gear. Thus the collier is adapted and fitted for coaling any ship.

Men-of-war can also use their collision mats rolled to form a fender. By these means, and with slight way on, the hawser from the collier to the ship being made fast on the inner bow of the former, in order to allow a stream of water to pass between the two, coaling at sea from a collier as described above would not be a very formidable operation, and in harbor would apparently meet all requirements.

A single apparatus can be applied easily to an ordinary collier, where the machinery can either be placed below by building a bulkhead, or on deck like an ordinary donkey engine. Supposing the vessel has two holds, one can be placed at each of them, and each apparatus can be made to discharge 100 tons an hour.

HIGH SPEED ON MERIDIONAL RAILWAYS.

RAILWAY cars running on north and south lines in middle and northern latitudes, when running south are moving away from the axis or center of rotation of the earth, and when running north are moving toward the axis.

It is evident by the most ordinary inspection that in all revolving bodies turning upon a central axis, the velocity of every zone from the center to the periphery is greater than any inner zone and less than any outer zone.

This is readily illustrated by a wheel or revolving disk.

Inspection of a revolving globe will give the relative motion as exemplified upon the surface of the earth.

When a train is moving to the south at great speed, it is constantly meeting this increased velocity of the earth, which crowds the train to the east, producing a tendency of the train to crowd against the western rail, or, if the speed was great enough, to run off the west side of the track. At or near the equator this condition ceases, as the earth is practically a cylinder, but the effect as above described increases for all latitudes up to the poles.

When trains are moving north, the effect is exactly reversed. The train is constantly meeting zones of less velocity of the earth's surface, and the difference in earth velocity makes the train lean toward the eastern rail, and if the train's speed is great enough, would derail the train to the eastern side.

In the southern hemisphere the north and south signs are reversed; the train running north meets western resistance, and when running south, eastern resistance.

In order to show the small value in a practical view of the broadly enunciated question as usually put, we give a computation of the real conditions of danger under the extreme train speed of 100 miles per hour and for the latitude of 45°, all lower latitudes showing more favorable effects than the figures given.

The approximate semi-diameter of the earth at the latitude of 45° is 3,962 miles, which, divided by 1·414, the ratio of the hypotenuse to one of the legs of a right-angled triangle, makes the radius of revolution of the earth's surface at latitude 45° equal to 2,802·0 miles; the spheroidal problem for latitude making a small variation from these figures, but does not materially affect the result — $2{,}802 \times 3{\cdot}1416 = 17{,}605{\cdot}0 - 5{,}276$ miles as the radial circumference of the earth at this point.

For a convenient train-run south on the meridian we take a distance of 10 miles in 6 minutes' time.

Leaving out the lesser equations for brevity as not affecting the general result, we make the 10 miles equal the hypotenuse of a right-angle triangle, which divided by 1·414, as for the greater triangle above, makes the radius of the earth's surface at ten miles south equal to 7·07 + 2,802 or 2,809·07 miles. Then $2{,}809 \times 3{\cdot}1416 = 17{,}649{\cdot}5088$ miles, the circumference at this point on the radial plane.

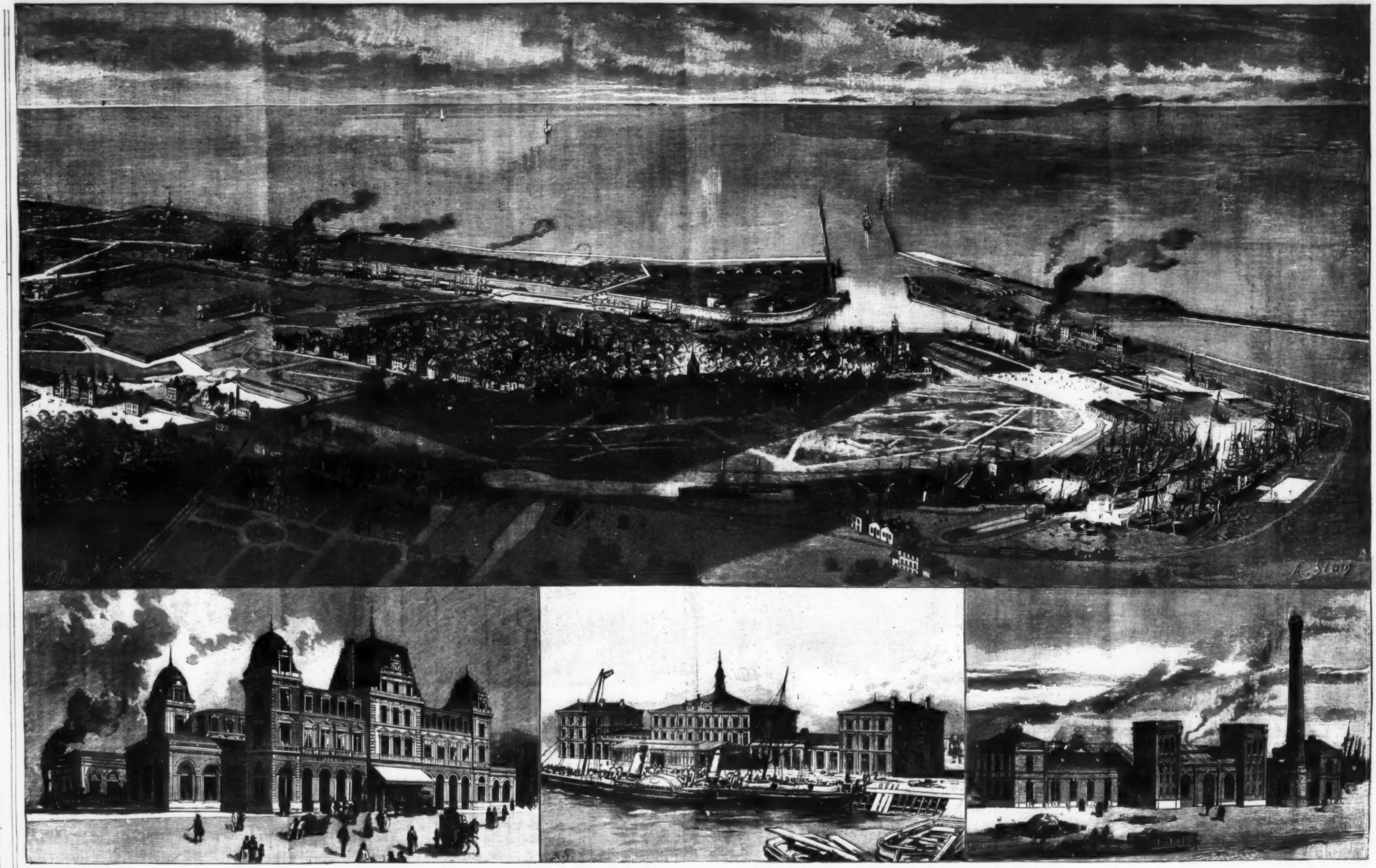
The difference of circumference of the two planes represents the difference of position of the meridional line for 24 hours, and when divided by the ratio for any given time will give the difference for the time specified. Then $17{,}649{\cdot}5088 - 17{,}605{\cdot}5276 = 43{\cdot}9812$ miles, which divided by 6 minutes' or $\frac{1}{240}$ of the earth's circumference in time, is $\frac{43{\cdot}9812}{240} = 0{\cdot}1832$ or $\frac{1832}{10000}$ of a mile that the south end of the track has advanced to the *east* during the run of 10 miles in 6 minutes—$5280 \times 0{\cdot}1832 = 967{\cdot}82$ feet, or 96·78 feet to the mile of $\frac{1}{10}$ minute's run at the above speed.

Trains at this high speed only on meridian lines would probably show excess of wear on the right flanges, and the right hand rails at points of highest speed would possibly also show excess of wear.

At the present moderate average speed of less than one-half as above stated, there has been no case, to our knowledge, of excessive wear, much less derailment, that could be traced to the differential motion of the earth's surface.

THE NEW PORT OF CALAIS.

ON the second and third of June, the president of the republic, accompanied by the ministers of the interior and public works, inaugurated the new port of Calais. The work of extending this port formed a part of the vast programme laid out by Mr. Freycinet in 1875, and was authorized by statutes of December 15, 1875, and August 3, 1881. The work as a whole, which is nearly finished and does the greatest honor to those who directed it—Mr. Vetillart, engineer in chief, and Mr. Charguerand, now engineer of the port—comprises an outer port, a floating dock, a graving dock, and a canal for internal navigation. The outer



1. General view of the city and harbor. 2. The central railway station. 3. Maritime station. 4. Buildings of the hydraulic machinery.

THE ENLARGEMENTS OF THE PORT OF CALAIS.

port is 558 ft. in width, and the largest vessels can maneuver in it without difficulty. The wharf north of this port is entirely appropriated to the service of travelers and of dispatches between France and England.

Owing to the excellent state of the Calais channel, it is now possible to have a service in this port at a fixed hour, at every hour of the day, and whatever be the state of the tide. The international trains can therefore regularly connect, through Calais, with the English trains, without delay through variations in the tide.

The wharf south of the outer port corresponds to desiderata of another kind. Owing to the great depth at which this wharf was founded, transatlantic vessels of as great a draught as 25 feet can remain here without stranding, even at low tide.

After this outer port comes the floating dock of 970,000 square feet area, the wharves of which have an extent of about a mile and a quarter. Communication between the outer port and the floating dock is had through two lock chambers in which, even at the lowest tide, enough water remains on the bed for ships of 25 feet draught. Vessels will therefore be able to enter the dock without remaining in the roadstead, no matter what day of the year it is.

An improved hydraulic plant will render unloading as rapid as in the great ports of England, and, as in these latter, vast sheds of an area of about 325,000 square feet will permit of the storage of all kinds of goods.

Finally, a graving dock 508 feet in length will give ships every facility for making the most extensive repairs. A vast river-boat basin connects the floating dock with the Calais canal, and by this latter with all the navigable ways of the interior of France and Belgium. The wharves of the outer port and docks are covered with railways, and upon the north wharf of the new outer port rises the new maritime station, built, as was the central station, after plans by Mr. Dunnett, architect of the Company of the North. The central station, situated between old and new Calais, contains, in addition to offices, a hostelry, with bed rooms and parlors. The maritime station permits passengers always to embark or disembark under cover, owing to the vast veranda, which puts the platforms in communication with a promenade gallery 410 feet in length.

Owing to this work as a whole, Calais is destined to see her maritime commerce rapidly develop; and for this city, which already contains 60,000 inhabitants within its boundary, we may predict a brilliant future.—*L'Illustration.*

THE AMERICAN PAPER BAG MACHINE AT THE PARIS EXHIBITION.

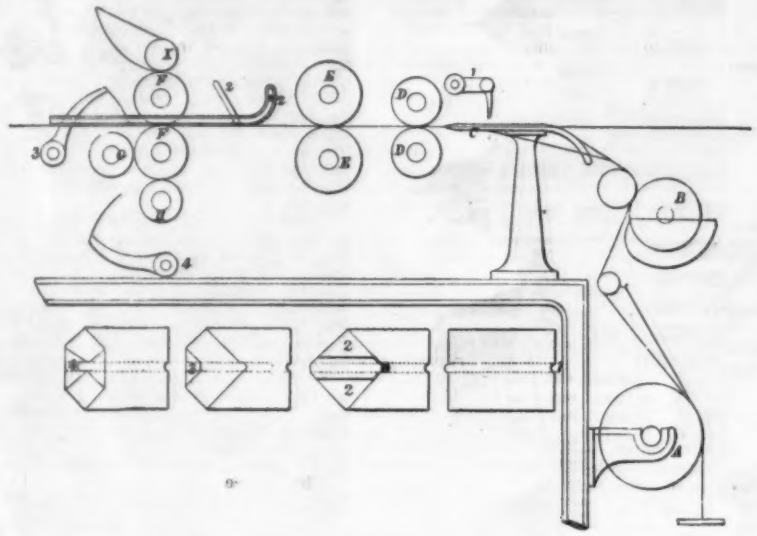
WE illustrate below a paper bag making machine which presents numerous peculiar features, and which has now been in practical operation for some time in several of the most important works in England, Scotland, and the United States. The object sought to be attained by the machine is the direct production of square or block bottomed bags of various lengths and widths from varying qualities of paper.

A single machine of this kind is capable of dealing with any quality of paper, and will produce bags dried and ready for immediate use, of various lengths and widths, at the rate of something like 7,000 per hour, the attention of a young girl being all that is necessary to operate it.

One of the exceptional advantages obtained by this invention is in making the bags without undue or superfluous pressure on the sides or folds; the tendency to split or burst, when being filled with goods, is consequently obviated.

form a lip or thumb piece in the bag, which is useful for readily finding the opening or mouth of the bag when made.

When the paper reaches the draw rolls, D, it has assumed the necessary tubular shape. The tucker blade, for the formation of the first or diamond fold, is so arranged that the edges of the paper, at the center of the fold, may be drawn more closely together to produce a square bottom. The tube from the first draw rolls to the tucker above mentioned is supported by a longitudinal reciprocating distending rod, which opens the forward end of the tube for the reception of the finger.



The tucker having laid and carried the diamond fold to the bight of the second rolls, F, the tube is severed by a pair of cutting rolls, E, while a segmental block, carried by a shaft and located between the two loose sections composing the top roll of the second pair of rolls, which are actuated at the same surface speed as the rest of the draw rolls, completes the diamond fold.

The length of the bag is determined by the increased or diminished speed of the several sets of draw rolls in excess of the severing rolls. The speed, however, of the latter may be increased or diminished immediately before and during the severance of the bag from the tube, in accordance with the speed or traverse of the tube.

For this purpose two disks are mounted and secured respectively to two separate shafts, one disk being provided with a slot in which a pin on the other is capable of moving, in such a manner that when the center of one shaft is lowered below the other, a variable motion will be transmitted to the slotted disk secured to and actuating the severing rolls.

The segmental block above mentioned receives paste from a trough of peculiar construction, through the medium of a suitable roller, communicating directly with the interior of the trough, through which it protrudes, the supply of paste being regulated by a slide plate at the bottom of the trough being moved, when required, nearer to or further from the said roller.

and during the severance of the bag, and in accordance with its speed of traverse.

To complete the formation of the bag, the two crossfolds of the bottom of the bag are yet to be laid. These are now creased and laid by two folding blades, acting respectively between the nip of two rolls. The whole of the varied operations of pasting, cutting, and folding being effected during the uninterrupted and continued traverse of the paper through the machine, effects a considerable increase in the manufacture of paper bags.

The various parts are lettered in the diagrammatic view as follows:

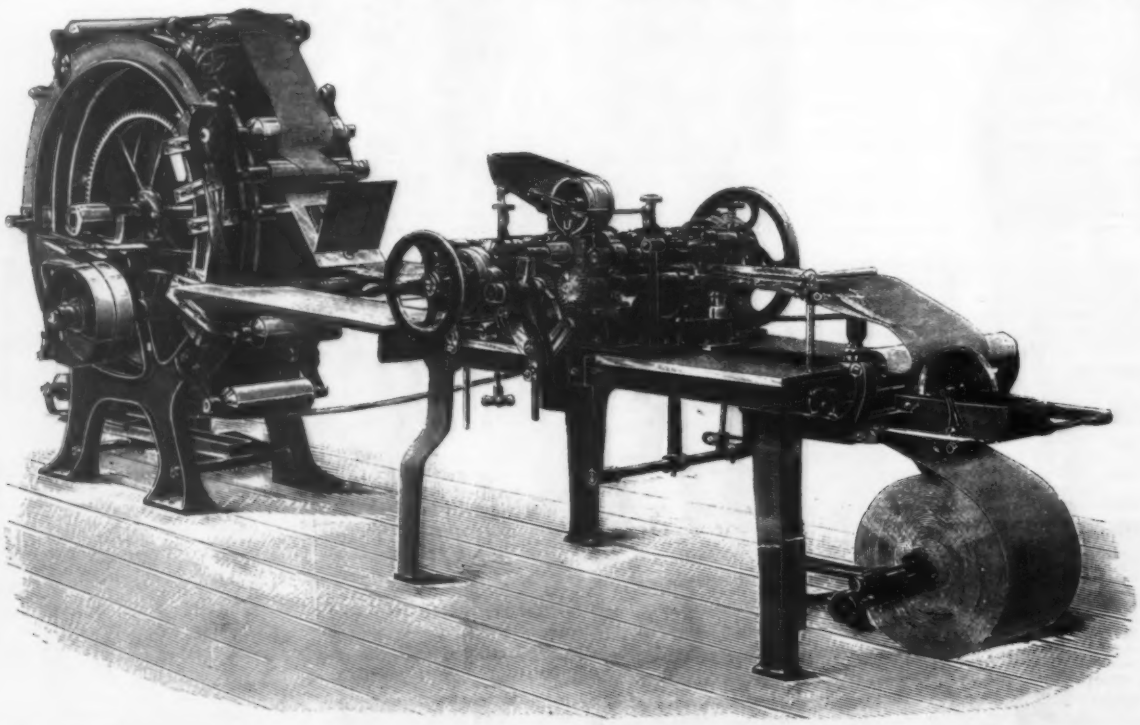
A, the roll of paper; B, paster to fasten tube as formed; C, tube former; D, draw rollers; E, cutter for severing the paper into lengths required; F, rollers for pasting and pressing down diamond fold, as shown in the detached view, 2, of the partly completed bag, dark lines showing paste; X, paste box and feed roller; G, roller for forming first bottom fold, as at 3; H, roller for forming last bottom fold, as at 4; 1, thumb bit cutter, as at 1 in the detached views, for opening the bags and giving an overlap to the bottom; 2, former for diamond fold, one-half the tube passing up the incline, the other half underneath, 2 strikes the paper at proper time and draws back the diamond fold and carries the bag into the bite of rollers F; 3, plunger assisting roller G to make the first bottom fold, as at 3; 4, plunger assisting roller H to form the last bottom fold, as No. 4.

The space taken up by this machine, which is the invention of Mr. Job Duerden, is about 13 ft. by 4 ft., and the power required about ¼ horse.—*Engineering.*

DECOMPOSITION OF STONES.

Report of Dr. G. W. HAWES to U. S. Government.

THERE are many more factors which determine the value of stones for purposes of construction than are often considered in the elementary treatises upon this subject, and the rules laid down are often determined



THE AMERICAN PAPER BAG MACHINE AT THE PARIS EXHIBITION.

To describe the machine, we may say that a roll of paper of a width suitable to the size of bag required is fixed in the position shown in the engraving at A. As the paper is drawn forward, paste is applied to the margin by an adjustable wheel, B, in the exact position required for the various sizes and with suitable pressure. In its traverse it is deflected in a trough-like form, and in this position a semicircular cut is made to

This paste block and the two severing rolls complete one revolution for one bag, whatever its length, the motion being determined by the surface speed of the several draw rolls, which is increased or diminished by the substitution of a change wheel of larger or lesser diameter, as may be required to determine the length of the bag to be made. The speed of the severing rolls may be increased or diminished immediately before

by the local circumstances. A more extensive study of building stones frequently vitiates the rules which apply in limited areas. It is, for example, stated that, in order to determine whether a stone will withstand the action of the weather, one should visit the quarry and observe whether the ledges that have been exposed to the weather are deeply corroded, or whether these old surfaces are still fresh. This is not a fair criterion, be-

cause the applicability of such a test is modified by geological phenomena. North of the glacial limit all the products of decomposition have been planed away and deposited as drift formation over the length and breadth of the land. The rocks are therefore in general quite fresh in appearance, and possess but a slight depth of cap or worthless rock. The same classes of rock, however, in the South are covered with the rotten products resulting from long ages of atmospheric action. They may be rotten to great depths, and the removal of the worthless rock is often difficult. This is due to the circumstance that no agencies have here operated to scrape off and remove the loose material from their surfaces in recent geological time.

There are other peculiarities of decomposition regarding which too absolute rules have been laid down. Pyrites is considered to be the enemy of the quarryman and constructor, as it decomposes with ease and stains and discolors the rock. But here, too, there are features which very seriously modify the effect of this decomposing substance. Pyrites, in sharp, well defined crystals, sometimes decomposes with great difficulty. If a crystal or grain of pyrites is embodied in soft, porous, light-colored sandstones, like those which come from Ohio, its presence will with certainty soon demonstrate itself by the black spot which will form about it in the porous stone, and which will permanently disfigure and mar its beauty. If the same grain of pyrites is situated in a very hard, compact, non-absorbent stone, the constituent minerals of which are not rifted or cracked, this grain of pyrites may decompose and the products be washed away, leaving the stone untarnished.

We believe that the microscopic study of these stones is, even in such simple cases as this, necessary for a correct determination as regards the influence of decomposing agents upon the stone.

Again, some of the constituent elements of rocks are so frequently found in a decomposed condition that they are considered to be deleterious, when present in large quantity, on account of their well known tendency to decompose. For example, olivine indicates a very marked tendency to decompose, as indicated by the vast accumulations of serpentine which are so frequently found to be a result of its decomposition; but the circumstances which in past time have brought about this decomposition may have been very different from those which indicate that it will decompose under the present influences. We wish to bring prominently forward that we consider that a decision as to the probable action of the agents producing decomposition in rocks should be largely dependent upon careful microscopic examination of the structure of the rock. Our experience has demonstrated that a rock of a given character, as regards ultimate composition and mineral constituents, may be easily affected by the weather if its constituent minerals, as indicated by their microscopic structure, are so fractured that they are laid open to atmospheric agencies through rifts, no matter how small, while the same stone, with the same constituents, may be eminently resistible to decomposing agencies if its constituent minerals are sound, whole, and impermeable, as indicated by the microscopic structure.

In the old world, where immense cathedrals, planned long ago, have been in the process of construction for hundreds of years, it has not been uncommon to see portions of the building fall into decay before the structure was finished, and the process of restoration often consumes large sums of money while the process of construction is yet going on. It thus very frequently happens that a variety of stones is used in the construction of the same building, because in this process of construction experience is gained indicating inapplicability of the stones used for durable structures. In this case it is experience alone which finally dictates the most suitable material; and even to this day, here in America, there is no other criterion to apply to a building stone save the test of experience, and the result is that buildings can be pointed to which, like those old, immense structures before referred to, are already crumbling while yet in the process of construction.

STRUCTURAL STRENGTH OF SEA-GOING TORPEDO BOAT No. 1.

CORRECTION.—In Table III. of the above article, published in SUPPLEMENT 704, the heading "Lines of Inclination" should read "Sines of Inclination."

INSTRUMENTS FOR DRAWING CURVES.

By Prof. C. W. MACCORD, Sc.D.

V. THE CYCLOID AND TROCHOIDS.

THIS apparatus consists of a rigid frame composed of two bars, F, F, and a rack R, parallel to each other and secured to two transverse pieces T T. The outer bars, F F, serve also as guides, upon which the carriage G G slides freely. In this carriage is formed the bearing for the wheel W, which engages with the rack R, and rolls along it as the carriage moves. To the shaft of W is secured the crank A A, formed of a rigid steel rod, upon which the socket B may be clamped at any distance from the center C, by means of a binding screw, not shown. This socket B is pivoted to a block which is formed in one piece with the pen-holder P; and this block slides freely in the long slot S S. This slot is formed in a bar which runs diametrically across the light ring H H, whose center is O, the point of contact of the pitch circle of the wheel W and the pitch line of the rack R. The ring H H runs freely in grooves cut in the circumferences of four rollers, L L L L, which turn upon pivots fixed vertically in standards borne by the carriage G G, and symmetrically arranged about the center O.

Thus by varying the effective length of the crank A A, the instrument can be adjusted to draw the prolate trochoid with its loop, as when the pen is at P, the cycloid with its cusp, if the pen be placed at Q, the prolate trochoid with its wave, if the pen be fixed within the pitch circle of the wheel as at I, or the right line if the pen be made to coincide with the center C.

And the pen being fixed in the holder with its edges at right angles to the slot S S, will always run in the true direction of the curve; for the point of contact being the instantaneous axis, the central line of the slot is always normal to whatever curve the pen may be tracing; thus O P, O Q, O I, are normal to the curves above named at the points P, Q, I, respectively, and O C is perpendicular to the path of the center, at C.

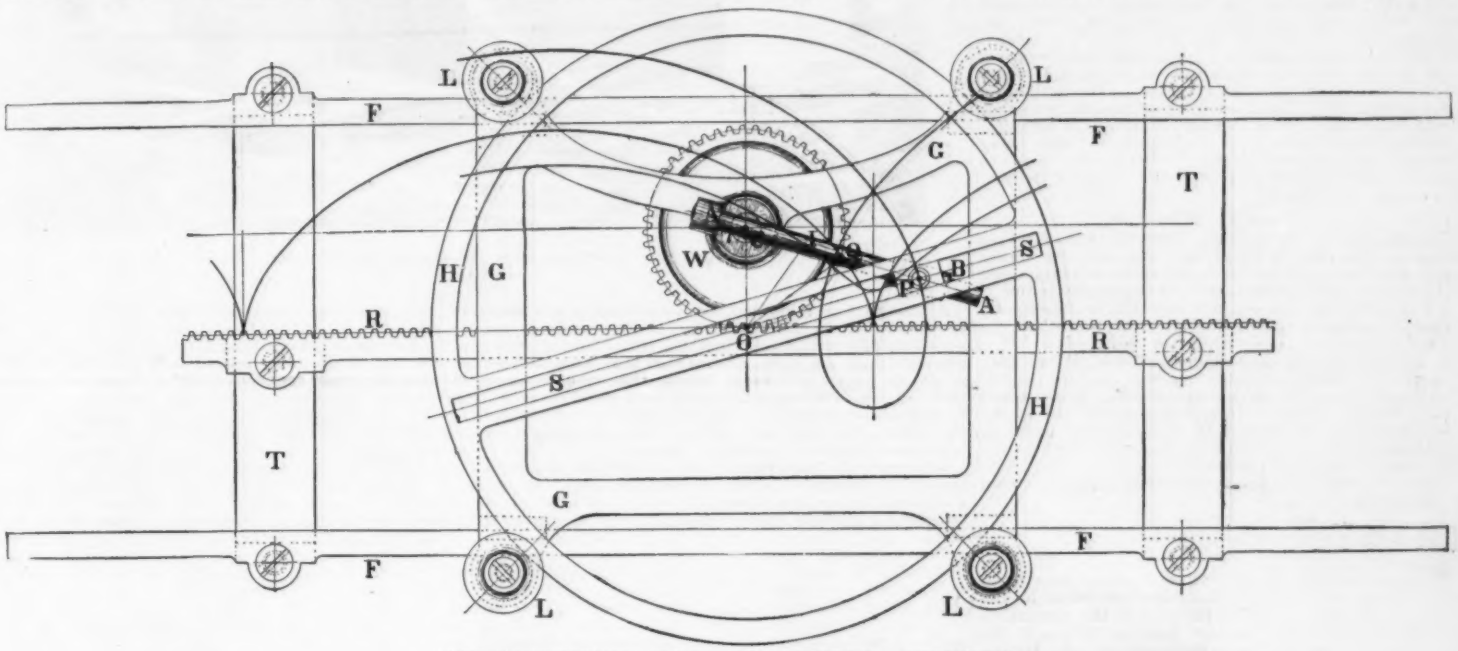
This device is the companion to the one for drawing the roulette spirals, described in the preceding article of this series (SCIENTIFIC AMERICAN SUPPLEMENT, No. 703) and illustrates the converse case. Here the marking point is carried by a circle rolling upon a fixed right line, while there it was carried by a right line rolling upon a fixed circle. And as in that case, so in this, it is to be understood that our purpose is merely to exhibit clearly the mechanical movements of the apparatus, which would require to be inverted and suspended above the paper were it to be actually constructed and employed for tracing these curves.

It may be of interest to note that when the crank arm is either greater or less than the radius of the wheel, the ring H H moves with a variable angular velocity, except when the crank is reduced to zero by fixing the pencil at C, in which case the ring will not turn at all. But when the pencil is fixed at Q, as in tracing the cycloid, the angular velocity of the ring is constant, and equal to half that of the wheel W. So that were a machine for shaping cycloidal cams to be constructed upon this basis, the action could be improved by the addition of suitable gearing to drive the ring at the required rate.

It may also be observed that the pen holder need not be formed in one piece with the sliding block, as above described. Instead of this, the sliding block, pivoted as before to the socket on the crank arm below, may be provided on the upper side with suitable means for clamping a supplementary block or arm capable of sliding in the line of the slot S; thus the pen holder, carried by this supplementary arm, may be set at any desired distance in the line of the slot, on either side of the crank pin.

If made in this way, the instrument will be capable of drawing not only the cycloid and trochoids, but curves at a constant normal distance from them, on either the concave or the convex side. Such parallel curves, when they lie on the concave side of the original or fundamental curve, sometimes present very curious and unlooked for features, as may be seen by reference to the SCIENTIFIC AMERICAN SUPPLEMENT, No. 420.

Upon the whole, then, this apparatus when thus modified, although capable of tracing the cycloid on only one scale, may be admitted to have a tolerably comprehensive range, in respect to the variety of forms which it can be made to delineate.



INSTRUMENT FOR DRAWING CURVES.

ON THE CAUSE OF THE ACCUMULATION OF "BLACK PASTE" IN STEAM CHESTS AND CYLINDERS.

By Prof. J. E. DENTON.

THE investigation of the above phenomenon has been a subject of continuous study by the Department of Tests at the Stevens Institute during the last two years. Certain large dealers in lubricants had received, from time to time, various complaints and reports of the formation or discovery of such deposits in engines in the lubrication of which their oils were employed, and it became desirable to learn whether the lubricants were responsible for the accumulation of the foreign matter. The result of the investigation warrants the conclusion that the deposits are not attributable to any particular quality of the lubricant used, but arise from the admixture of solid matter with the lubricant, the solid matter being brought into the engine cylinder from the boiler by the steam, and precipitated from the latter by cylinder condensation.

The general course pursued in the investigation is therefore regarded as possibly of general interest to all steam users, and the following account of the matter is therefore presented by consent of the parties for whom the work has been executed. Without their persistently stimulative aid and liberal expenditure of money, such problems as the one under notice could not even approximate solution.

I. Samples of "deposits" collected from locomotive cylinders, from stationary engines of various sizes, running under various conditions, and located in various parts of the country, and from marine engines, all showed an avarage composition, by chemical analysis, as follows:

	Per cent.
Oil, animal and hydrocarbon, part free and part combined with lime, lead, manganese, etc., about	40
Iron, or iron oxide, about	20
Lime, magnesia, lead, silica, zinc, copper, etc., about	40

From these it was concluded that the oil and iron might be accounted for by the use of the lubricant and possible wear of cylinders, but that the forty per cent. of foreign matter must come from the boilers.

II. A large compound blowing engine at an iron works broke its piston ring through the accumulation of a hard black deposit under the rings. The same deposit was found throughout the cylinder passages and in the receiver. The oil used was the purest petroleum, yet the analysis of the deposit showed considerable animal oil. Upon investigation, it was found that the boilers took water from a stream just under a grating where there was always an abundant accumulation of all sorts of animal grease. The grease could only have reached the engine cylinders through the boilers.

The engine had not had its cylinders open for a long period, and the boilers were seldom cleaned, as the works ran night and day, and the plant was overloaded. The hypothesis that the boilers sent over foreign matter to the cylinder, which contaminated the lubricant, was, therefore, further supported by this instance. Specific knowledge was accordingly sought of the condition of the interior of the boilers in the case of some engine making a deposit.

III. Such knowledge was best available in the case of transatlantic steamships, whose boilers are examined thoroughly every voyage. Accordingly, arrangements were made with the Red Star steamship line to investigate the interior of the engines and boilers of the steamship Noordland, over a series of voyages.

This ship was using the purest quality of high grade petroleum as a cylinder lubricant. In the receiver, low pressure piston, and throughout the condenser and air pumps, there was an abundant accumulation of black deposit of the consistency of putty, which, on analysis, showed the same average composition as given above. The writer was permitted to change the oil to a mixture of petroleum and a large percentage of the finest neatsfoot oil, but no marked change occurred in the amount or character of the deposit, which continued to be about one-half oily matter and the remainder a heterogeneous mixture of iron, silica, etc.

Upon examining the interior of the boilers, it was

found that during each voyage (of twelve sailing days) all surfaces within the range of water level were covered with deposits, and in some places over one inch thick, which, upon analysis, showed practically the same qualitative composition as the deposits in the cylinders. A deposit scraped from the edges of the incisions in the dry pipe, where steam enters the latter and becomes isolated from the main space of the boiler, showed a composition of half oil and half miscellaneous matter, precisely similar to the cylinder deposits. All evidence, therefore, was still consistent with the hypothesis that the miscellaneous matter in the cylinder deposits had their source in the boiler. Such matter must then go over with the steam, notwithstanding that by distillation water is ordinarily supposed to rid itself of impurities.*

IV. To settle the matter, steam was collected in glass bottles from the steam chests of the Noordland, during a voyage to Antwerp, and an analysis made of the steam thus condensed. The result was the discovery that the steam, on arriving at the engines, contained 10 grains of solid matter to the U. S. gallon, and the composition of the solid matter was about one-half oil, ten per cent, iron, and the remainder the same heterogeneous mixture of lime, silica, zinc, etc., found in the cylinder deposits; the oil being fed to the steam before the steam was collected.

The qualitative chain of evidence proving that the foreign ingredients or "dirt" in the cylinder deposits originate in the lack of cleanliness of the boiler being thus fairly complete, it remained to test the theory.

1st. By considering whether the 10 grains per gallon of solid matter could furnish as much of the latter as was represented by the total amount of deposit found throughout the engine per voyage.

2d. By learning if a clean boiler would fail to make a deposit with an oil which was known to have been used in a large number of engines which had shown deposits in the cylinder or steam chest.

V. Ten grains of solid matter to the gallon is, roundly, 10 pounds of solid matter to each 58,000 pounds of water. The engines of the Noordland used about 60,000 pounds of steam per hour. The total solid matter represented by 10 grains per gallon would therefore account for fully 10 pounds of "dirt" per hour passing through the cylinders. But it is probable that only that portion of the solid matter mixes with the oil which is contained in the steam which condenses to liquid in the cylinders. The minimum cylinder condensation of such an engine is probably about 15 per cent. of its total consumption of steam.

Hence, about $0{\cdot}15 \times 10 = 1{\cdot}5$ pounds of "dirt" may be supposed to be precipitated, including the oil fed to the cylinder.† This would make the cylinder deposit per voyage of 12 days

$$12 \times 24 \times 1{\cdot}5 = 430 \text{ pounds.}$$

This amount is probably six times the amount ever found in the cylinders,‡ pumps, etc., but the figure shows that the solid matter in the steam is amply able to afford as much accumulation as is actually found.

VI. Regarding the second test of the theory by means of a clean boiler, the latter was found in the case of a sectional boiler using very pure water. The deposit annually in these boilers of 50 H. P. capacity averages less than a pailful of hard, insoluble chips. The engine was of the non-condensing, high speed type. Analysis of the steam condensed at the steam chest before the oil mixed with it showed one grain of solid matter per gallon, and the amount of steam did not exceed 400 pounds per hour.

Hence, the total solid matter entering with the steam per hour was

$$\frac{400}{60{,}000} = \tfrac{1}{150} \text{ pound.}$$

The oil was fed to the cylinder at the rate of $\frac{1}{10}$ pound per hour. Seven months' use produced no deposit of any kind. Now, in the case of the steamship Noordland, the solid matter passing through the steam per hour was one-half the weight of oil. Hence, in the case of the steam boiler the proportion of oil to "dirt" was three times as much as in the Noordland; consequently, if the oil itself possessed any property tending to produce the formation of deposit, the latter should have appeared more readily in the case of the steam boiler than in the case of the steamship.

The general conclusion, therefore, is that deposits of "black gum," etc., in engine cylinders are not caused by absence of any proper quality in the cylinder lubricant, but by the contamination of the latter with dirt, which may be furnished by the boiler if the latter in any way accumulates foreign matter upon its interior surfaces.—*Stevens Indicator.*

* Evidence that steam does not entirely free itself of the solid impurities in water is afforded in the finding of steam pipes in heating plants almost entirely plugged through the accumulation of solid matter carried along with the steam. See account of heating plant, etc., by the writer, in the *Stevens Indicator* for October, 1888.

† The wearing away of the surfaces of the cylinders should, of course, be included in the estimate of possible deposit; but on computation it is found that the most liberal allowance for wear would create a weight of iron less than one-half per cent. of the weight of oil used. So that the wearing of the surfaces is not a material factor in the problem.

‡ The deposit in the boilers is larger than this amount, but the feed water, which contained 90 grains of solid matter to the gallon, is amply able to account for the entire boiler deposit, including allowance for surface blowing.

EDISON'S NEW PHONOGRAPH.

SINCE the epoch at which the celebrated American inventor Edison patented his first phonograph, he has not ceased to introduce into it improvements of a nature to better its operation and increase its practical utility.

In our issue of January 21, 1888, we exhibited to our readers the form of the apparatus that it seemed as if the inventor had finally decided upon, and for which, as in the beginning, innumerable applications were foreseen.

It is necessary to believe, however, that Mr. Edison did not consider his apparatus perfect, for he has continued to work on it ever since; and it seems that perfection has now been nearly reached, judging from the enthusiastic reception that the apparatus had at the Academy of Sciences at its session of April 23, when Mr. Janssen presented it in the name of Edison and of his representative, Colonel Gouraud.

The new apparatus, Fig. 1, contains several improvements, which are well indicated in Mr. Janssen's note, which we here quote nearly *in extenso*.

The principal improvements introduced into the new phonograph are three in number. In the first place the single part designed to produce, under the influence of the voice or of instruments, impressions upon the cylinder, and afterward to reproduce the sounds by the action of the cylinder, has been divided into two. This division appears to me very happy and very important. It permits of much more precisely adapting the part to the special function that it has to fulfill. Thus, in the new apparatus, the inscription of the vibrating disk is made by means of a style whose point is so fashioned as to cut the quite ductile material of appropriate consistence that forms the new cylinders. There results from this action of the inscribing style a shaving of extreme delicacy, and, upon the cylinder, a furrow that interprets the most delicate motions of the disk vibrating under the action of its generator.

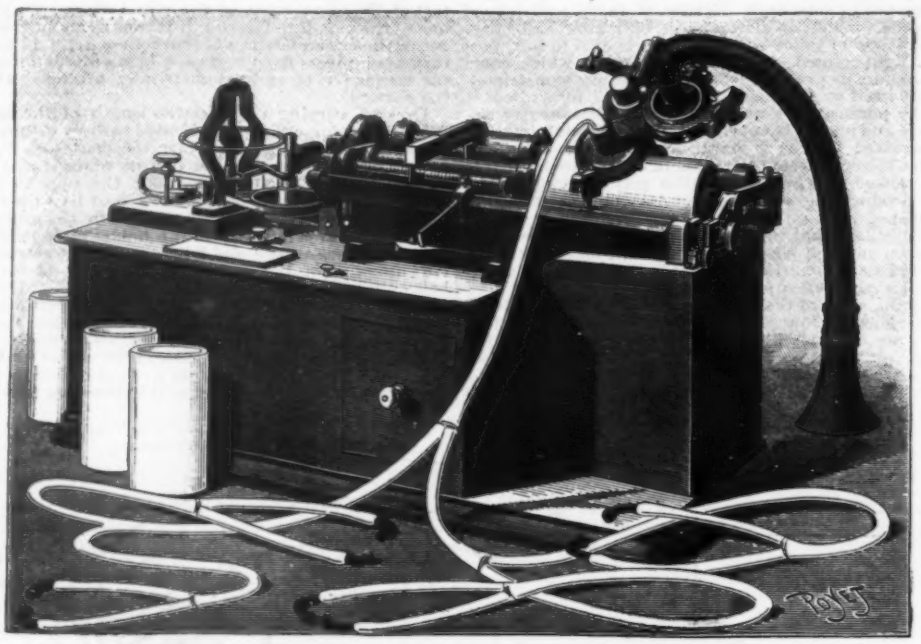


FIG. 1.—EDISON'S NEW PHONOGRAPH.

Although the style has been so constructed as to produce a furrow that interprets as accurately as possible the motions of the vibrating disk, the reproducing style and disk have, on the contrary, been contrived for the reception of their vibrating motions from such furrow without alteration; and Mr. Edison has so well attained this end that it is possible to reproduce the speech inscribed an almost unlimited number of times and without perceptible alteration.

It is precisely these points that I have just spoken of that have received the recent improvements to which I alluded in the beginning. I do not believe myself authorized to enter into any more details in regard to them.

The replacing of the tinfoil by a plastic substance which can be cut with great precision and without requiring any appreciable stress is also very happy.

The third very important improvement regards the motions. In the old apparatus, it was the inscribing cylinder that moved, but in the new one it is the small device that carries the disks and styles. The motion is given by electricity.

A ball regulator provided with a brake permits of obtaining variable velocities and, consequently, a more or less rapid emission of the sounds. But in all cases, the apparatus is so perfectly constructed that the sliding motion of the styles and the rotary motion of the cylinder can be rapidly put in accordance, which latter should be very perfect for a proper emission of the sounds and the preservation of the cylinders that bear the inscriptions. Thus it is possible to retard or quicken the emission of sounds, or interrupt and resume at such a point as may be desired, or to begin the entire emission over again as many times as desirable.

The phonograph seems especially qualified for reproducing sharp sounds with surprising perfection; yet I must admit that the sounds of the voice of quite low tonality have been very well reproduced. The fact must not be lost sight of that Mr. Edison, in his new instrument, has endeavored to obtain perfection in the reproduction of sounds, and not their power. So acoustic tubes should always be used for hearing the sounds well.

It is very interesting to find that the phonograph is capable not only of registering all the sounds of the musical scale and those that are introduced through the speaking of various languages, but also the sounds of an entire orchestra presented simultaneously for inscription.

I am persuaded that, aside from the uses that the new instrument will be put to, and which will increase beyond anything that we can now foresee, the phonograph will become the starting point of important studies in acoustics and molecular mechanics. It is, therefore, a splendid problem that Mr. Edison has solved, and all the friends of progress and science owe him a tribute of admiration and gratitude.

In September, 1888, the new phonograph was already improved enough to allow Mr. Janssen to send Mr. Edison the following "phonogram" from the meeting of the British Association:

"The problem of artificially reproducing the human voice is one of the most astonishing ones that man has ever proposed to himself. The genius of Mr. Edison gives us the solution of it, and his name will be blessed by all those who will be able to hear again the loved voices of those whom they have lost. It is the first French voice that, under this so new a form, has traversed the Atlantic."

This sending of a French phonogram to America followed closely on the phonogram sent from America by Edison to Col. Gouraud, then at London. In this letter, one heard Edison speaking, coughing, laughing, and finishing his letter by expressing the pleasure that he would have in hearing his representative (Gouraud), instead of tiring himself with reading his bad writing.

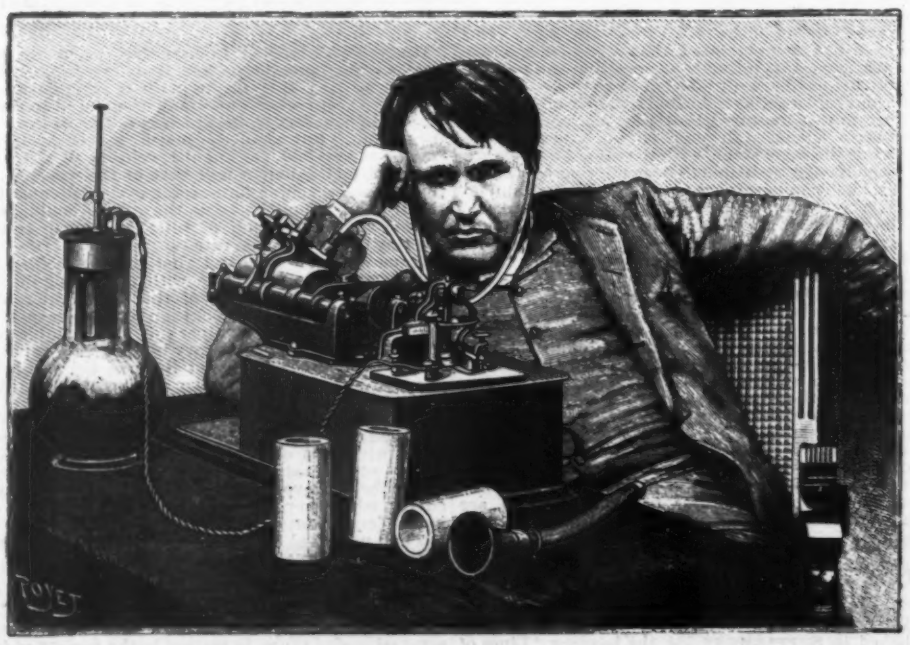


FIG. 2.—EDISON LISTENING TO THE FIRST PHONOGRAM SENT FROM ENGLAND.

Since that epoch, phonograms have succeeded one another, and we can no longer count the speaking letters exchanged between the old and new world.

The improved phonograph has now become a practical instrument of daily utility. It daily serves as a stenograph to which is dictated the answers to letters received, and which the apparatus reports at leisure to an employe whose duty consists in transcribing what he hears, and whose entire science is limited to writing properly, under phonographic dictation, and either with a pen or typewriter. The phonogram may even replace printing office manuscript, and dictate the copy directly to the compositor—an application that has already been made of it in America and England.

Of the other applications pointed out by Col. Gouraud in a note that the Academy has done the honor of an insertion *in extenso*, we shall enumerate the following few:

Postal transmission of phonographic messages in phonograms.

Preliminary registration of the speeches of statesmen, lawyers, preachers, etc.

Repetition of solos by actors and singers, with a view to correcting articulation and pronunciation.

Preservation and indefinite repetition of the voices of celebrated men, of the farewells of the dying, of the words of a beloved relative, etc.

One of the most curious experiments that the new Edison phonograph, combined with the motograph and carbon transmitter, has permitted of carrying out is telephonography, that is to say, the transmission to a distance and the phonographic inscription of a phonogram.

The programme of the phonographic session that followed the communications of Messrs. Janssen and Gouraud merits special mention. It was as follows:

Speech of Mr. Janssen and of Mr. Berger, addressed to Mr. Edison. Messages from the correspondents of some French journals at London addressed to their editors. A few words in the following languages: French, English, Spanish, Italian, Dutch, Greek, Latin, Syriac, Turkish, Hebrew, Arabic.

Music.—La Marseillaise played by the military band of the Queen's Guards, Hail Columbia played by the same band. Marche du Regiment, a cornet and piano duo, the music by Gounod. Duo of cornets-a-piston. Gounod's Ave Maria, sung, and accompanied by himself.

The session terminated with felicitations sent phonographically by the Academy to the fortunate inventor, and with the desire to see him soon at Paris on the occasion of the Universal Exposition.—*La Nature.*

NEW ELECTRIC LAUNCH.

THE electric launch Malden, designed and moulded by Mr. W. Sargeant, of Strand-on-the-Green, Chiswick, W., was, during the past summer, an object of interest on the river Thames, especially during the Henley and Maidenhead regattas. This carvel-built craft shown in the illustration is 30 ft. 6 in. long, 4 ft. 10 in. beam, with a draught of 2 ft. 4 in. aft and 22 in. mean. The electrical energy is stored in 48 accumulators, contained in ebonite boxes, which are placed in lead-lined trays under the seats. The midship sections of the vessel being perfectly flat, in the event of the craft taking the ground, the acid contained in the cells is not likely to slop over. Twenty-four of these cells are arranged on each side of the boat, and with one charge contain electrical energy sufficient to propel the launch for ten hours, at about ten miles per hour. The motor is a 6 in. Immisch, rotating at about 550 revolutions per minute, and calculated to give about 2¾ brake horse power.

In the counter of the launch is placed a resistance frame, and over that, upon the deck, are fixed two switches, one for starting the motor, and the other for reversing, both being under the control of the man steering. The ammeter and voltmeter are also in his view.

The motor is fixed under the floor aft, and is connected with the accumulators, which are worked in parallel. In place of the objectionable whistle of the steam launches a large and melodious ship's bell (Jensen's patent), which is in every way efficient, is placed on the fore deck as shown in illustration, and sounded electrically by the steersman, the current being supplied direct from the accumulators. All lights—port, starboard, and head lights—are incandescent lamps, all supplied from the accumulators.

All the accumulators being placed under the seats, a clear space is left from stem to stern, which will accommodate twelve comfortably. In fact, the interior of the Malden, fitted as she is with well-stuffed cushions and a good awning, becomes one continuous and agreeable lounge. The seats are removable, so that the accumulators may be easily examined if necessary at the time of charging, which is proposed to be accomplished during the night. The charging can be done at a reasonable cost from charging stations, which are now being constructed and placed up the Thames by Messrs. Immisch & Co. The first of these stations was designed by Mr. Sargeant, and in all appearance resembles one of the large house boats common on the Thames. It consists of a river barge 70 ft. long by 14 ft. beam, on the floor of which, upon a suitable foundation, is placed a semi-portable compound steam engine of 25 horse power nominal

Countershafting placed in the fore part of the barge is driven direct from the flywheel, which runs at 120 revolutions per minute. This countershafting drives the dynamos which, through insulated copper heads, supply the current to the accumulators in the launches moored alongside the station. The engine is covered with a large lantern in the roof, which can be quickly removed if at any time it is necessary to take the engine out.

Electrical power for river launches is now an established fact on the Thames, and will probably be much improved during this year. Messrs. Sargeant & Co. are constructing three very elegant electric launches, one of which is expected to be the fastest ever produced, which will contain accumulators provided by the Electrical Power Storage Co. The motor is specially designed for water propulsion, and will be fitted with Sargeant's patent motor shaft and thrust block combined, which is self-lubricating and reduces friction to a minimum.

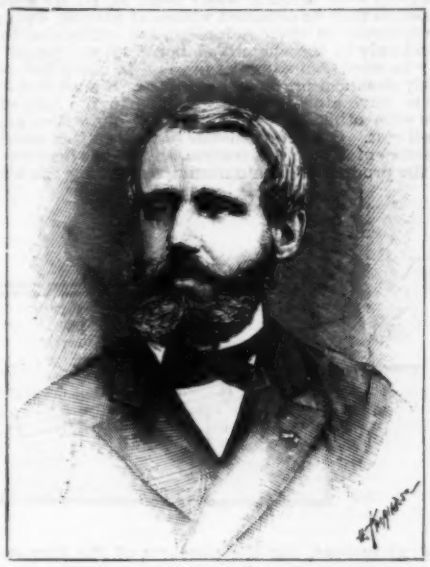
One launch can be seen in the course of construction at the Kew Bridge charging station, near Kew Bridge. The next charging station above Kew Bridge is situated opposite the water works at Hampton, and is the floating one before mentioned. And it is also proposed by this firm to construct a station above Richmond Bridge. There will be no difficulty in obtaining sufficient energy at any one of these stations for a run of 50 or 60 miles, according to the capacity of the accumulators contained.

The annexed illustration is executed from a photograph of the Malden in Bray Lock on her journey from Cookham to Kew Bridge, which was accomplished with one charge of electrical power.—*English Mechanic.*

NEW ELECTRIC LAUNCH.

GASTON PLANTE.

IN current electrical literature one of the most familiar names is that of Gaston Plante, who died suddenly at Paris on May 24. No article on the storage battery is complete without a statement to the effect that the principal work of Plante's life was his investigation into the voltmeter, the practical result of which was the invention of the storage cell with lead plates. Plante experimented upon all conceivable metals and combinations of metals to be used for electrodes in voltmeters, and the result of his numerous tests was to show that lead is, all things considered, the best active material from a practical point of view, though the amount of energy which he found possible to store per unit of weight was greater in the case of some other metals. Plante was born in 1834 at Orthez. His scientific studies were pursued at the Conservatoire des Arts et Metiers, in Paris. He took a position as a laboratory assistant, and soon began an investigation into the nature of electro-polarization, which led to the discovery of the accumulator



GASTON PLANTE.

The immediate cause which prompted him to undertake his first long series of investigations was not the desire to find a storage battery, because in those days the application of dynamos to electric lighting was still unknown; it was the desire to study the effects of electric discharges of great quantity, which were not attainable with frictional machines and Leyden jars. The discovery of the lead accumulator was, so to speak, a by-product of his investigation.

Plante continued for many years to add to the number of cells in his possession; he studied their progressive formation with keen interest, and as he had to rely chiefly upon the Bunsen battery for his charging current, the process was both tedious and costly. Many of his experiments on the discharge were of the most brilliant and even daring character. His eyesight almost failed him for a considerable time before his death, and the cause was ascribed to too close application to experimental work. He was by no means blind to the possibilities of the practical application of the lead battery, and among other suggestions for its use he referred at an early date to the electric light, although in an era before Swan and Edison were known, and when the dynamo was scarcely as yet a commercial machine. He was unable to foresee the full importance of the suggestion.

He also invented what he called the "machine rheostatique," being essentially a commutator which, on being turned by a crank, rapidly changed the grouping of the secondary cells from parallel to series. Of late years Plante devoted himself almost exclusively to the reproduction of meteorological phenomena in the laboratory by electrical effects, and he has succeeded in thus imitating hail, globular lightning, etc. His latest publication was a small book on this subject, printed a little over a year ago, and he has also contributed to the exhibition at Paris some very interesting apparatus and specimens in connection with this work.

In 1881 M. Plante received the Diplome d'Honneur at the Paris exhibition, and he was also made a Chevalier of the Legion d'Honneur. A little later the Academie des Sciences conferred upon him the "Prix Lucaze," and he also received the Medaille d'Ampere from the Societe de Encouragement pour l'Industrie Nationale.

The honors which were showered upon M. Plante during the latter portion of his career did not induce him in any way to modify the quiet and retired life which he had led for so many years. Nearly his whole time was passed in his laboratory in the Rue des Tournelles, where, however, a kindly welcome was assured to every visitor, more especially to such as happened to take an interest in the pursuits in which his attention was absorbed.—*Western Electrician.*

WILLIAM TEMPEL.*

G. V. SCHIAPARELLI.

WILLIAM ERNEST TEMPEL, astronomer at the observatory of Arcetri, died on March 16, after a long and painful illness.

His life was a notable example of a strong calling drawing man with overwhelming force to a fixed object, and surpassing the greatest obstacles.

Born of a poor family, Dec. 4, 1821, at Nieder-Cunersdorf, in upper Lusatia, he early learned the art of lithography, which he followed at first in many cities of Germany, and attained in it great ability, united with delicate artistic feeling.

Endowed by nature with an imaginative and restless temperament, after a time he left his fatherland to seek his fortune in foreign countries. He lived three years in Denmark, then came to Italy; and in 1859 we find him living in Venice. At this time began his interest in astronomical matters. He purchased with his savings a telescope from Steinheil, not a very large one, to be sure, but very good, and he was soon recompensed by his first discovery, the comet of 1859. In the same year he began to make a map of the well known group of the Pleiades, in which in a short time were included six large stars and many hundreds of smaller ones.

How many telescopes since Galileo had been turned to that part of the heavens! Yet, aided by the excellence of his instrument and by uncommonly keen vision, Tempel there found that which in 250 years, with telescopes of every size, none had been able to see. He discovered the famous nebula of the Pleiades, whose existence is even now doubtful to many, and he was harshly disputed by those who in astronomy—as is often the case in other departments of knowledge—claim to be the highest critics.

Lately, however, celestial photography has come to confirm the observations of Tempel, and not only removes every doubt of the existence of that nebula, but shows that what Tempel saw is the brightest and thickest part of a nebulous mass extremely complicated and extensive, which extends through nearly all the space occupied by the group of the Pleiades and forms one mass with it. He thus showed in a convincing way the close connection existing between the nebulæ and the stars, and utterly destroyed the belief, still held by Humboldt in his Cosmos, that the nebulæ are collections of stars of a high order, in extent and formation like the milky way, and situated at a much greater distance than ordinary stars.

In 1860 Tempel went to live in Marseilles, and in 1861 served awhile as assistant in the observatory there under the direction of Benjamin Valz. In that position he remained only six months. Loving above everything his own independence, he continued to follow his profession as engraver in that city until 1870, alternating these labors with astronomical investigations. In Marseilles he discovered six small planets, Angelina (64), Maximiliana (65), Galatea (74), Eurynome (79), first discovered a little before by Watson in America, Terpsichore (81) and Clotho (97); at that time those discoveries had greater fame and greater importance than would be given to them at present. It was then indeed reasonably supposed that the number of the smaller planets between Mars and Jupiter was limited; this does not seem likely to the present astronomers, already embarrassed by the mighty army of "*atomi planetarii*," now increased to about 300, and of which no one can see an end. Most important to astronomy were, and always will be, his discoveries of comets, in which he was especially assisted by a very keen eye, the perfect climate of the Provence, and the Steinheil telescope of excellent clearness. These are the comets discovered by Tempel in Marseilles: 1860 IV, 1862 I, 1863 IV, 1864 II, 1866 I, 1867 I (with Stephan), 1867 II, 1869 II, 1869 III, and 1870 II (with Winnecke); these gained for Tempel several prizes from the Imperial Academy of Vienna.

Of these the most important, from the result to which it led, was 1866 I; which, rather than a comet, should be called a remnant or the ruins of a comet. In the course of the destruction of that body came the thick swarm of bright meteors of November, which at

* From *La Nazione* (Italian), April 5, 1889. Translated for the *Sidereal Messenger* by F. W. Fiske, of St. Paul.

periodic intervals of 33 years meet and surround the earth, producing bright showers of falling stars. We have finally learned the cause of such a phenomenon, which, from the year 902 of the common era even until to-day, has occurred so many times and always been seen with new wonder; and to this progress not a little has been contributed by Tempel's discovery of that burning comet in a very favorable time, just in time to explain the last return of meteors, which was in the night between the 14th and 15th of November, 1866.

The stay in Marseilles marked a very calm and very fruitful period in the life of Tempel, to which, unfortunately, the political whirlwind of 1870 put too early an end.

Expelled from France for no other offense than that of being a German, in the beginning of 1871 he went to Milan, where he was established as assistant in the Royal Observatory of Brera. Then giving up the art of lithography, he gave himself wholly to science, and in his new field of work engaged in useful labors. In the four years that he stayed in Milan (1871 to 1874) he discovered four more comets, 1871 II, 1871 V, 1871 VI, 1873 II. Besides these, he observed and drew several other comets, particularly the splendid one of Coggia, that appeared in 1874, whose appearance he represented in a way that has not yet been excelled.

Though so tireless a hunter of comets, Tempel in the number of his discoveries did not rival Pons, to whose life his own presents many analogies. Yet it may be said that no astronomer has made discoveries in this line more important and more useful.

I have already shown how timely and how fruitful in its results was his discovery of the comet 1866 I; to this I should add that, of the ten comets of short periods yet known, three are due to Tempel. The story of these comets belongs to the most interesting part of astronomy. The changes through which, by the powerful attraction of the larger planets (for the most part of Jupiter), they were drawn in periods sometimes not very distant to become lasting members of the planetary system; the exact forces whose application has caused these disturbances through the planetary bodies; the notions that some of them have given and can still give in the future about a supposed resisting ether filling all the heavenly space; and, finally, the destruction that one of them, Biela's, and perhaps also Vico's, has suddenly undergone, as if before our eyes separating into small fragments; all these questions give to these bodies of feeble light and modest appearance a degree of importance not inferior to the largest and brightest comets.

His age and the state of his health made his labors very severe, continuing nightly observations in the trying climate of Milan; and in the beginning of 1875 he was led to accept the position of astronomer in the new observatory founded by Donati a few years before in Arcetri, where he lived and worked alone, expecting a definite arrangement at that fine observatory. There at first he continued his assiduous investigations of comets; his last discovery in this field was the comet 1877 V. Finding himself entirely his own master and having two large telescopes by Amici that were distinguished for the clearness of their images, he gave himself, with the zeal that he put in every act, to the study of the nebulæ, whose forms and details he represented in a large number of drawings, which are the finest and the most accurate yet made in this line.

For this labor he was thought, in 1880, worthy of the royal prize which the Royal Academy gives every six years to astronomical work. So perfect are these drawings that Tempel in vain sought an artist capable of reproducing them satisfactorily to him; and they are among his unpublished works; but their existence and their value are not unrecognized in the astronomical world, and already a movement has been made in Germany to acquire and publish them.

The reason for so great an interest in them is not hard to find, for besides an eye skilled in astronomy, Tempel had a practiced artist's hand—two qualities that are rarely both found to so high a degree in the same person. The drawings of the nebulæ that he left are, in the opinion of all who have seen them and compared them with the heavens, a faithful representation of the appearance presented by the nebulæ to a telescope of the present time. Therefore they can give to astronomers in the future a means of judging upon the question of the possibility of change in these bodies; which perhaps we could now do, had there been a Tempel provided with a telescope upon the Nile with the builders of the pyramids, or in an observatory upon the roofs of the temples of Babylon. It is then of great importance not to allow to perish or become forgotten a work whose value will always increase with the ages.

One might think that photography applied to representing the heavenly bodies would now render useless drawings made by the aid of the telescope. But let me say that is an error; for those rays or vibrations of light by which the heavenly bodies are made visible to the human eye are generally different from those other rays by means of which these bodies are figured upon photographic plates. So it can happen that a star in which at first sight prevail rays of great intensity appears very bright to our eyes and yet acts with feeble impression on the plate of the camera. On the other hand, another heavenly body, whose light abounds in chemical rays, can act with strong effect upon the photographic plate and yet be hardly visible to the human eye, or entirely invisible. There are such essential differences existing in the character of the light emitted by different stars, and also by different nebulæ; and they can exist in different parts of the same nebula, which will appear of different aspect whether seen by the eye or photographed. A remarkable instance is seen in the case of the nebula of the Pleiades, which in a photograph shows an appearance quite different from that seen through the telescope. Not only therefore will the drawings of the nebulæ made by the eye in the usual way never be useless, but when they are compared with the photographic impressions there will rise very instructive ideas about the different characters of the nebulæ.

In the last years of his life Tempel was obliged to give up entirely night observation as too fatiguing to his declining health. The impossibility of completing these tasks, which would bring him the greatest fame and happiness, contributed not a little to increase his illness. After a year's sickness a sudden crisis ended his sufferings on the 16th of March, 1889.

Although Tempel had not received a regular education, he was not wholly without culture; he had a strong love of nature and art, and poetry made a strong impression upon him. In mathematics he had, without the aid of teachers, and by himself, mastered the first steps, and was never troubled in making the needed calculations.

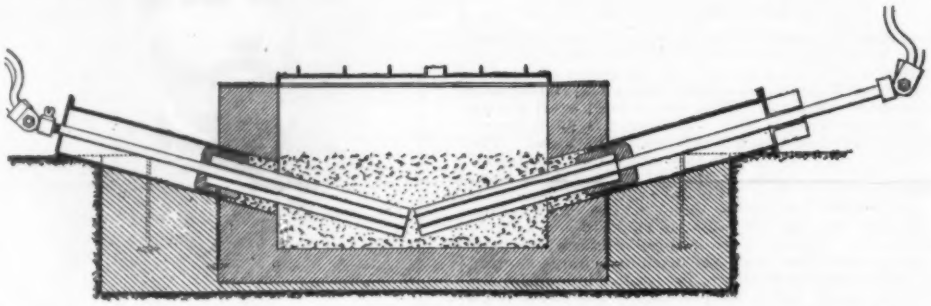
His honesty of character made him worthy of high esteem; but his mind was very sensitive and ill-fitted to bear the inevitable disagreements caused by daily contact with his fellows; nor had he learned the necessary art of bearing them philosophically. He often kept himself brooding over injuries, and sometimes without any real cause; and this produced the impression in those who did not know him that he was a distrustful and unaffable man. Only a long acquaintance with his character could correct this judgment and give a just estimate of his faults, which injured no one but himself and were fully compensated by the strength of his noble qualities.

His friends cannot forget his pure and disinterested love which made of a humble workman a wise astronomer, gaining for his memory a name that will last as long as the study of the heavenly bodies is held in honor by men.

ELECTRICAL SMELTING AND PRODUCTION OF ALUMINUM.*

By Mr. WILLIAM BOBY, London.

YOUR worthy chairman has asked me to give you a description of the Cowles process of electrical smelting and the production of aluminum. I feel great pleasure in doing my best to bring the subject fully under your notice, it being one which, I think, is destined to play an important part in metallurgy as applied in practical matters, and more particularly to the calling which this institution represents. Although the process is at present employed almost solely for the production of aluminum alloys, it appears probable that its uses may be extended over a much wider field, as, by its agency, materials may be obtained which, at present, owing to the difficulty in their reduction, are curiosities to be found only in the chemist's laboratory, and possibly it may be employed where at present, in many instances, costly chemical processes are in use. Silicon and chromium have already been obtained in the form of alloys with other metals in practical quantities and at small cost. Other rare metals have also been obtained experimentally; but attention, so far, has been turned to the production of aluminum, as offering the widest field, at present, for the products of the furnace. I propose, this evening, to describe the Cowles furnace and its action, then to give you some account of the machinery for producing the current, and afterward to say a few words respecting the products obtained by the use of the process.



The works of the Cowles Syndicate Company, Limited, are at Milton, near Stoke-on-Trent. The cut shows a section through the longitudinal center of one of the furnaces built in the beginning of 1888. I may mention that the inventors, Messrs. Eugene and Alfred Cowles, being engaged at their American works, the selection and arrangement of plant, and the erection of buildings, furnaces, etc., was placed in the hands of myself and my partner, Mr. S. G. Browne, and carried out by us between October, 1887, and April, 1888. You will observe that the furnace consists of an oblong receptacle, the internal dimensions being 5 feet long, 3 feet 3 inches deep, and 20 inches wide. It is built below the floor line, and lined with fire bricks. Into the ends are built cast iron tubes, inclined, as shown, for convenience in working the electrodes. On the ends of the tubes are covers having bosses upon them, through which pass the electrodes. On to the covers are screwed blocks of wood surrounding the bosses. Near the outer ends of the electrode rods are easily removable clamps, each of which holds a nut, through which passes a screw having a T handle at its outer end, while its inner end rests against the wooden block. The rotation of this screw moves the electrode inward or outward. The top of the brickwork is covered by iron plates, and an iron cover, as shown, is placed over the mouth of the furnace. In the cover is a hole through which the gases issue as they are driven off by the heat in the furnace. The electrodes consist of carbon rods 2¼ inches in diameter, and nine of them are attached to each electrode rod. The attachment, as shown on the drawing, consists of metal which is cast around the ends of the carbons and of the electrode rod, so as to form a conductor, which is in perfect contact with the whole of the parts connected. The metal from which this attachment is cast is selected to be suitable for the alloy which is to be dealt with in the furnace, as, although in comparison with the actual charge it is not subjected to a very intense heat, yet the metal of which it is formed is found to exercise a slight influence upon the furnace product.

Here, then, we have a covered furnace, provided at its ends with two electrodes, which are capable of being easily moved apart. As you will see, it is extremely simple, without complication of parts, and built entirely of very cheap materials, excepting the electrode rods and carbons, the former being of copper and permanent, while the cost of the renewal of the latter is a very small item in comparison with the amount of work done. The application of the furnace is as follows: The two electrode rods are connected to the two leads of the dynamo, the cable, connected to the positive pole, sending the current into the left hand electrode, whence it travels through the charge, where it meets with the resistance which causes the heat, and passes by way of the right hand electrode into the cable connected to the negative pole of the dynamo. The resistance is caused by the particles of carbon which are mixed in the charge. Thus, it will be seen, the current acts independently of the structure of the furnace itself, acting simply on the charge which is in immediate contact with the carbon by means of which the heat is produced. The heat developed is enormous, and, of course, fire bricks have no capability of withstanding it. Charcoal is found the most convenient form of non-conductor of which to form a protective lining, but the intensity of the heat converts it in a short time into graphite, so that it loses its non-conductive properties. To renew the charcoal lining frequently entailed considerable expense, and formed a difficulty which was overcome by dipping the partially graphitized charcoal into limed water, the lime being found to render the charcoal again sufficiently refractory. The process of liming is as simple and cheap to carry out as it is satisfactory. The charcoal is put into a cistern of limed water, and afterward dried in a revolving steam-jacketed cylinder. When charging a cold furnace, some charcoal is put into the bottom and lightly beaten down till it forms a fairly firm bottom of sufficient thickness. The electrodes are run inward till their ends nearly meet in the furnace, and the charge is then put into the center of the furnace, and surrounding the electrode ends. The charge for copper alloy consists of close upon 300 lb. of materials, about one-fourth being ore broken up small, about four per cent. of carbon, a good deal of which is supplied by means of broken-up slag taken from a former heat, slag to the amount of about ten per cent. being introduced, and the balance copper. If iron alloy is required, the charge consists of a larger proportion of slag, and the iron is broken into small pieces. The copper is granulated by being poured when in its molten state into water.

The ore employed is sometimes corundum, a sample of which is on the table, and which for some time was the only ore employed by the Messrs. Cowles in their process; but at present the ore employed at Milton is bauxite, which after repeated experiments was found to answer equally well and at a fraction of the cost. The charge, while being inserted, is prevented from spreading out laterally, in which case some portions of it might be too distant from the electrodes, by two pieces of sheet iron, connected by a distance piece, which are placed one on either side of the electrodes; the charge is put in between them, and charcoal is then filled in between the sheet iron and the sides of the furnace, after which the sheet iron is withdrawn, the top of the charge covered, and the ends of the furnace filled up with charcoal to the depth of a few inches above charge and electrodes. Then the iron cover is adjusted over the furnace and luted round its edges with fire clay to render it as gas tight as possible, and the furnace is ready to receive the electric current. The full amount of current is not applied at first; the engine is started at a moderate speed, so as to provide about 2,000 to 3,000 amperes. This finds its way through the charge and gradually heats it and the lining immediately surrounding the ends of the electrodes. As the ore and metal of the charge become fused, the resistance decreases, when the speed of the engines is gradually increased, and the electrodes drawn apart until the whole of the ore and metal in the charge is fused, before which time, having a larger body of materials to act upon, we have the full 5,000 amperes of current flowing through the charge. Immediately after the electrodes are withdrawn the necessary distance, and the entire charge is fused, which takes an average of one hour and thirty minutes to one hour and forty minutes, the engine is slowed to a few revolutions per minute, the shunt-exciting current is switched off the magnets, so as to break the field, and the brushes are raised; the electrode rods are then disconnected from the leads and another furnace is connected to the current. The slowing down of the engine, disconnection and reconnection of leads, and starting again occupies a few minutes only.

As soon as the current flowing through the furnace begins to produce a considerable heat, a light smoke commences to rise from the hole in the top cover. When it has reached a fair volume, a light is applied and it burns brightly, the gas given off being carbonic oxide, which, although of an explosive character, simply burns quietly, though vigorously, as it comes off. If the lid be raised immediately after the engine is stopped, the heat is seen to be of a very intense nature. On the first occasion of this kind at Milton, Mr. Eugene Cowles, who was present, remarked to me that we probably had before us the highest temperature that had ever been produced in England. No method has at present been devised for obtaining any idea of the temperature; it seems probable, however, and indeed there can, I think, be little doubt, that the metals in the charge are volatilized, after the more volatile oxygen has been driven off, and, rising in that condition from the neighborhood of the electrodes, meet the cooler portions of the lining and become precipitated, the metallic alloy being found in the form of a slab on the charcoal lining below the electrodes. It is assumed

* Paper read before the Cleveland Institution of Engineers, December 17, 1888.—*Iron.*

that the aluminum combines with the metallic base of its alloy while both are in the gaseous condition; it is certain that the alloys formed by this process possess a completeness of union between their component parts, a homogeneity and strength, which, as far as we can ascertain, is superior to those qualities as found in aluminum alloys otherwise compounded. The furnace, as illustrated, had to be allowed to cool before the contents could be removed and the charge renewed. This was a source of loss and delay, and an improved set of furnaces is now in use, of similar form to that in the drawing, but raised above the ground, and having a tap hole from the side into the interior, by means of which the metal is run out in a molten condition. The furnace also is recharged without being allowed to cool, a most important economy being thus effected over the original method.

The production of aluminum at the Milton works is at present about 200 lb. of actual aluminum per day of twenty-four hours, when the aluminum is produced as an alloy with copper, or, if the alloy has iron for its base, a less amount is obtained, being about 150 lb. The average number of runs per day of twenty-four hours is about twelve to fourteen, so that we obtain about 15 lb. to 18 lb. of pure aluminum (embodied in the alloy) per run, when producing bronze. The attendance required upon the furnace is small; two lads attend to the adjustment of the electrodes for the regulation of the current, and to the connecting to and disconnecting from the dynamo leads; while two men weigh out the ore, etc., charge the furnaces, and run the molten metal off. The ferro-alloy frequently comes from the furnace complete and ready for the market, but in some cases it contains a proportion of the charcoal lining mechanically mixed with it, in which case it is remelted in an ordinary furnace, when the charcoal floats on the surface and is easily removed. The cupro-alloy comes from the furnace in the form of a nearly pure white metal, which is highly charged with aluminum, but which, by a very simple process, is fused and mixed with the necessary amount of copper to form a bronze of the grade required.

Before going more particularly into the subject of the finished products, I will give a description of the machinery employed for generating the current. The boilers are two in number, of the well known Babcock & Wilcox type, made at their Glasgow works. They answer the purpose well, working day and night, there being no spare boiler. They are fired by means of Juckes' mechanical stokers, and burn rough slack coal, obtained in the neighborhood. The coal is quite unscreened and contains a large amount of dust. The performance of the boilers is very creditable. They are 145 horse power nominal each, and as the engine often indicates 500 to 540 horse power for a considerable time together, it speaks well for their steaming qualities that they supply it with sufficient steam. They supply, besides, steam to three small engines on the works, and a small quantity for other purposes. The engine is compound and condensing, of the tandem form, having cylinders 23 inches and 43 inches diameter, with a stroke of five feet. It draws its condensing water direct from the canal. The engine was built by Messrs. T. Bates & Co., and is a finely designed and well finished machine. It is built with a special view to high speeds, and runs ordinarily at from 66 revolutions per minute at the commencement of the run to 80 revolutions per minute toward the end of the run. Its valve gear is not of the trip kind, but all three slides are moved by eccentrics, the high pressure slide being of the piston form, with another piston valve inside it for regulating the cut-off. The current is subject to considerable irregularities of flow, which are sometimes very sudden, and the efficient regulation of the engine is of great importance. The governor acts by turning the piston expansion valve, and is quite successful in controlling the engine within very narrow limits. An arrangement is fitted to the governor, by means of which the speed of the engine can be varied at will. We selected this gear as being more suitable for such quick running than the trip gears now usually found on engines of this size. The engine runs with such absence of noise that, standing with one's back to it, it is hard to believe that it is working. The fly-wheel is twenty feet in diameter, its periphery being grooved by ropes, by means of which the power is transmitted to the dynamo. The engine is evidently working under conditions unfavorable to economy, owing to the variations in the amount of current required by the furnace; but I found on a careful test, extending over a number of runs, that the consumption of the common slack coal named above, and including the intervals between the runs, only amounted to 3 1 lb. per I. H. P. per hour. An electrical apparatus worked by a small battery is fitted to the stop valve, so that the steam can be turned off the engine instantaneously by pressing a push button, several of which are fixed to the wall and the columns in the neighborhood of the dynamo and the furnaces. The apparatus opens a cock in the condenser, and breaks the vacuum at the same time that the steam is shut down. Thus the dynamo and furnace tenders can at once stop the engine, should it be found desirable to do so, without having to signal to the engineman.

The dynamo furnishes probably the largest amount of current of any machine in existence, its normal output being 5,000 amperes at a tension of 60 volts. It was built by Messrs. Crompton & Co., and is of the constant current type, with drum armature. The shaft is of steel, 7 inches in diameter, and carried in three bearings, two of which are placed on either side of the driving pulley and one outside the commutator. The driving pulley is 4 feet diameter, grooved to correspond with the fly-wheel; its weight is about 2 tons. The central part of the shaft is larger, having been made 14 inches diameter, but is planed down to 10 inches, leaving, however, four ribs projecting, and these ribs act as keys to carry round the core. The core consists of disks of Swedish iron about 18¼ inches diameter, 900 in number, making a total length of core of about 36 inches. The winding upon the core consists of 128 radial copper bars seven-eighths of an inch deep and three-eighths thick at the top. They are coupled at the ends of the core by means of crescent-shaped bars on a system patented by Crompton and Swinburne so as to form 32 conductors. The whole arrangement was thought by its designers to be one which would avoid any considerable amount of heating of the armature, but in practice this result has not been obtained, and a fan is now employed to send a strong current of air of considerable volume through the armature. The winding bars were originally held by thirty-two projecting steel pins, fixed to the core, but these gave way and were replaced by double the number of larger size, and made from the Cowles Company's 10 per cent. aluminum bronze, with a strength greatly exceeding that of steel. Bands of steel wire are wound over the bars to hold them tightly to the core. The commutator has 64 parts, is 20 inches long, with a center tightening ring on account of its length. It is fitted with eight brushes, mounted on a separate ring, and the current is carried off by a large number of strips of stencil copper. The field magnets are of soft wrought iron of the double type, placed horizontally. There are four turns of 1½ inch by 1 inch copper bars round the magnets. The machine is wound in series with shunt coils, which excite the field magnets, and a current is produced with a potential proportionate to the speed of the engine. A separate dynamo was used at first to excite the field, but it is now unnecessary. The ordinary full working speed of the armature is 380 revolutions per minute, though it is frequently run up to 400, the normal output of 5,000 amperes and 60 volts being then somewhat exceeded. Occasionally also the current jumps for a moment to a very high point, owing probably to metal in the charge fusing in such a way as to suddenly give the current a considerably freer passage. The lubrication of the bearings is effected by castor oil and water. A safety cut-out is provided between the dynamo and furnace rooms. It is calculated to fuse at 8,000 amperes.

In the furnace room is a current indicator having a dial fronting to the furnaces and another one on the other side of the partition wall in the engine room. It consists of a solenoid of nine turns, which was made by casting a cylinder of copper and then cutting it spirally by means of a parting tool. The whole of the current passes through this coil, which is interposed in the main positive lead. The core of the solenoid is geared to the dial spindle. The markings of the dials were made by actual experiment after the dials were in place; they extend to 5,000 amperes, which amount of current sends the hands about two-thirds round the dial. Tapped from the main lead is a pilot light suspended over the dial in the furnace room, and which gives light for reading the latter. The main leads from the dynamo consist of bars of copper 3 inches by 1 inch; there are three of these alongside each other in the furnace rooms from each pole of the dynamo, and they are slightly over 50 feet long in one piece. From these depend flexible cables connected at one end with the electrode rods, and at the other to flat bars, which are clamped between the bars of the leads, and provided with wheels which roll along the top edges of the leads for convenience in shifting the connections from one furnace to another.

Very few hands are required to work the process proper. Besides the two boys, and two men named as attending to the furnace, we have one man each to engine, boilers, and dynamo; one man and one boy employed in preparing and moving charcoal; two men in the foundry, who standardize bronze and cast ingots, and an occasional electrode holder, and who also attends to the remelting when required of the ferro-alloy. There are, besides, other men employed, as there would be in any other works, such as a carter, fitter, carpenter, night watchman, and store keeper; altogether when working double shift as at present, about twenty-five men and boys. The plant at Milton is small at present, but there is ample space on the site and in the main building for extension. I found, by tests taken over a series of runs, that one pound of actual aluminum in the bronze alloy is produced by 20 electrical horse power and in the ferro-alloy by about 28 electrical horse power. Improvements in the details of the process have gradually lowered the amount of horse power since the commencement, and no doubt more is to be done yet in this direction, more particularly by the employment of a still larger volume of current, which is in contemplation, when more machinery shall be put down.

Turning now to the products of the furnace, we have two principal alloys. I will first call your attention to the ferro alloy. This, as already mentioned, is ready for the market as it runs from the furnace, or is rendered so with very little expenditure of labor. The amount of concentration of the alloy is not an important point, so long as it is definitely known, the use of the ferro alloy being entirely for mixing with other iron, either cast or wrought, or (which indeed appears to be its greatest field of usefulness) with cast steel. The selling price of the ferro alloy is regulated by the amount of its concentration, which is at present decided by analysis. It is, however, possible that it may be ascertainable by other means; for instance, we already know that when the concentration exceeds a certain amount the alloy becomes non-magnetic, not being attracted by a loadstone. This is a property which may possibly be found to be of practical value. A valuable property of aluminum, as produced by this process, here comes into play, viz., we can melt up any desired quantity of the ferro alloy and be quite certain that an analysis of a few grains of it will represent the concentration of the entire bulk. This quality of equal diffusion is of high value when it is considered that by its means a ladleful of, say, molten steel will be impregnated with a minute proportion of aluminum if a small quantity of the broken-up alloy has been placed in the bottom of the ladle before the steel was poured in. The combination of aluminum with the iron having taken place in the electric furnace, it has never been in contact with oxygen, and the very thin film of oxide which at once forms upon the pure metal when exposed to the atmosphere, and which causes considerable trouble in dealing with pure aluminum, does not come into existence in the alloy.

The use of ferro-aluminum has not up to the present obtained any large dimensions in this country; in the States it is already largely in use. The effect of the alloy upon steel is to raise its elastic limit and ultimate strength, while it lowers its melting point and facilitates the making of sound castings—this latter point will be recognized as of great importance. This alloy is employed by the makers of the "Mitis" castings in America, who obtain it from the Cowles Company's works at Lockport, and by the makers here, who obtain it from the Cowles Syndicate Company. The sale of this alloy in America has reached considerable dimensions. My partner, when spending a few days at the Lockport works a few months back, saw an order come in for 10 tons, and when it is borne in mind that 0·1 per cent. of aluminum is an ordinary proportion to add to steel castings, it will be seen that this represented operations of some magnitude (1,000 lb. steel receives 1 lb. of aluminum, or 10 lb. of 10 per cent. ferro-aluminum). The effect of ferro-aluminum upon puddled bar iron was investigated by Mr. G. W. Thompson, of Messrs. P. & W. McLellan's firm, with most satisfactory results. The tensile strength being raised to 31 tons with 22 per cent. elongation, he states that the quality is equal to that of the finest mild steel. The paper by Mr. Keep, of the Michigan Stove Company, which appeared in *Iron* of September 21, 1888, bore testimony to remarkably beneficial effects of the Cowles Company's ferro-aluminum as applied to cast iron; his tests also show that after the iron had been cast the aluminum remained in it, and continued to influence it beneficially even after several remelts. It has been held by previous investigators that under such circumstances the aluminum passed off; if so, Mr. Keep's experiments show the superiority in this respect of the electrically formed alloy over that made by mixing pure aluminum in the ordinary manner. Mr. Keep is the head of one of the largest stove-making concerns in the States, which now advertises that aluminum is employed in all its castings, reaching about 60 tons of stove plates per day. English firms are commencing to use the alloy, and no doubt its use will rapidly extend. Some of the best-known steel founders are now employing it in England.

(To be continued.)

ON ALLOTROPIC FORMS OF SILVER.

By M. CAREY LEA, Philadelphia.

SILVER is capable of existing in allotropic forms possessing qualities differing greatly from those of normal silver. There are three such forms, or rather three modifications of one form, differing from each other in many respects, but all more nearly related to each other than any one of them to normal silver. One of these forms is soluble in water, passing readily to an insoluble form, and this last may, by the simple presence of a neutral substance exercising no chemical action upon it, recover its solubility. Another form closely resembles gold in color and luster.

Whether metallic silver shall be reduced from its compounds in its normal or in an allotropic form depends upon the reducing agent applied, so that it cannot be said with any certainty whether it exists in its compounds in its ordinary normal form or in an allotropic condition; the latter alternative seems at least equally probable.

These allotropic forms of silver are broadly distinguished from normal silver by color, by properties, and by chemical reactions. They not improbably represent a more active condition of silver, of which common or normal silver may be a polymerized form. Something analogous has already been observed with other metals, lead and copper.

Much having been written, especially within the last few years, on the products of the reduction of silver compounds, a brief summary of what has appeared may be desirable before proceeding further. The study of this subject has led to remarkable divergencies of opinion on the part of the chemists engaged in it. Almost all the views advanced have been successively disproved by each subsequent publication. It follows that what has obtained a place in the text books is almost wholly incorrect.

The earliest experimental work was Faraday's, but his product has been proved to be a mixture.* The next was the well known paper of Wohler, published in 1839. It is not my purpose here to enter upon a criticism of this memoir. If this illustrious chemist succeeded in obtaining by the means employed a true citrate of silver hemioxide—as would appear from his analyses—no chemist since his time seems to have done so. The next publication to Wohler's was that of Von Bibra, who used Wohler's method and, while affirming that he obtained a similar citrate, found an entirely different constitution for the corresponding chloride. For instead of obtaining a hemichloride Ag_2Cl, he gives as the result of 15 concordant analyses the constitution of his product as Ag_4Cl_2.† A citrate, to yield such a chloride (if such a chloride exists), by the simple action of hydrochloric acid, could scarcely have the constitution assigned to it by both Wohler and V. Bibra.

In 1882, Pillitz published two papers.‡ He commences by disputing the probability of the existence of Ag_4O on grounds of valency; namely, as implying that oxygen may be quadrivalent. Although it is very doubtful that any one has up to the present time obtained Ag_4O, the argument seems futile, as are many arguments deduced from supposed laws of valency. Similar reasoning would make Ag_2Cl impossible, which substance undoubtedly exists, and it would also deny the existence of K_4Cl, which stands upon such authority as that of Rose, Kirchhoff, and Bunsen.§ Pillitz carefully examined the so-called hemioxide precipitated by alkaline solutions of antimony and tin, and could find no trace of Ag_4O in any of them. He did not examine Wohler's products.

The first person to deny categorically the existence of Wohler's series of hemi-compounds of silver appears to have been Dr. Spencer Newbury. In two interesting papers,| he describes a repetition of Wohler's methods and declares it to be impossible to obtain products of constant composition. The red solution taken by Wohler to be argentous citrate, Dr. Newbury concludes to be a suspension of finely divided silver. Muthmann ¶ after a careful examination of Rantenberg's products, concludes that that chemist was wholly in error in asserting the formation of compounds of chromic, molybdic, and tungstic acids with silver hemioxide. He next studies the red liquid obtained by Wohler's process, and comes to the same conclusion as

* G. H. Bailey and G. J. Foster, Chem. Soc., 1887, 418. Bericht d. ch. G., xx, Ref. 309.

† Erdmann, J. prakt. Chim., 1875, 120, 39. Von Bibra precedes his paper with a brief summary of the conclusions reached by previous chemists on the subject of the action of light and chemical reducing agents on silver compounds. The collection is interesting as showing to what inconsistent and even contrary opinions careful observers have come on these reactions.

‡ Zeitschrift fur an. Chemie, xxi, p. 27, p. 406.

§ Gmelin Kraut, ii, 1, 72.

| Am. Chem. Jour., vi, 407; viii, 196.

¶ Bericht der d. ch. Ges., xx, 963.

Newbury, that it consists of finely divided silver suspended in water.

I shall not dispute the correctness of this opinion in the case of the liquid examined by these two chemists. At the same time, I cannot accept the tests of solution employed by Muthmann. That a substance will not pass through a dialyzer shows that it is colloidal, and is no proof whatever that it is not in solution. Animal charcoal takes up many substances from true solutions. Decolorization by animal charcoal is no proof whatever that the color removed was not in true solution. By freezing, the molecular condition of a substance may be changed. Muthmann found that when the red liquid was mixed with gum water and precipitated by alcohol, the precipitated gum carried down with it the red substance, thence deducing that it was only in suspension. This conclusion is scarcely justified. A solution of litmus was mixed with gum water and precipitated with alcohol; the mass of the litmus went down with the gum, a trace only appeared in the filtrate. With Hoffmann's violet, the same result. Yet no one, I think, will assert that these two substances do not make true solutions in water. Even, however, if these arguments could be admitted, they would not apply to the solutions presently to be described, which can be proved by optical means to be true solutions. I propose presently to show that silver may exist in a perfectly soluble form, dissolving easily and abundantly in water. Starting from this, it may show all degrees of solubility down to absolute insolubility, still however existing in an allotropic form and quite distinct from normal or ordinary silver. The solutions formed are as perfect as those of any other soluble substance.

Wohler's process was next repeated by G. H. Bailey and G. J. Foster, who came to the conclusion that no citrate of hemioxide was formed, and that Wohler's results must be rejected.

Von der Pfordten* endeavored to obtain hemi-compounds of silver by acting on the nitrate with an alkaline solution of sodium tartrate, and also with phosphorous acid. His determinations were made volumetrically, based on an opinion that a permanganate solution acidified with sulphuric acid would dissolve silver hemioxide, but not metallic silver. Previously to receiving his paper I had found that sulphuric acid, even diluted with ten times its bulk of water, was capable of acting on finely divided normal silver and of dissolving an easily recognized quantity. V. d. Pfordten's conclusions were thus vitiated entirely. It should however be remarked that the difficulties of the subject are extremely great. In his last paper† this chemist abandons his views as to the existence of silver hemioxide, so that at the present time the formation of Ag_4O by Wohler's method, or by any other known method, is admitted by no one. That such an oxide may exist appears by no means improbable. The existence of Ag_2Cl and K_2Cl seems almost to involve that of Ag_4O and K_4O. This latter product Davy believed that he had obtained. The black substance which V. d. Pfordten formerly regarded as Ag_4O he now takes to be silver hydrate Ag_4H_2O.

The reduction products described by V. d. Pfordten are strongly distinguished from those which I shall presently describe by two decisive reactions:

1. None of his products could be amalgamated with mercury (l. c., 2296). All of mine readily amalgamate.

2. None of my products give off the slightest trace of gas when treated with dilute sulphuric acid. All of his do so (l. c., 2291).

Moreover, the difference of appearance is extremely great.

Early in the year 1886, I took up the study of the reduction products of silver in connection with that of the photo salts. I commenced with Wohler's process, giving it up after a few trials as affording no satisfactory results, and sought for a more reliable means. This I found, in March, 1886, in a reaction which I still use; namely, the reduction of silver citrate by ferrous citrate. At first, however, the results obtained were most enigmatical, the products very unstable, and impossible to purify. Much time was lost and the matter was given up more than once as impracticable. Eventually, by great modifications in the proportions, stable products and capable of a fair amount of purification were got. Even the earlier and less pure forms were exceedingly beautiful; the purer are hardly surpassed by any known chemical products.

The forms of allotropic silver which I have obtained may be classified as follows:

A. Soluble, deep red in solution, mat lilac, blue, or green while moist, brilliant bluish green metallic when dry.

B. Insoluble, derived from A, dark reddish brown while moist, when dry somewhat resembling A.

C. Gold silver, dark bronze while wet, when dry exactly resembling metallic gold in burnished lumps. Of this form there is a variety which is copper-colored. Insoluble in water, appears to have no corresponding soluble form.

Properties possessed by all the varieties in common and distinguishing them all from normal silver.

All these forms have several remarkable properties in common.

1. *That of drying with their particles in optical contact, and consequently forming a continuous film.* If either is taken in a pasty condition and is spread evenly over paper with a fine brush, it takes on spontaneously in drying a luster as high as that of metallic leaf. C when so treated would be taken for gold leaf. But this property is much better seen by brushing the pasty substance over glass. When dry, an absolutely perfect mirror is obtained. The particles next the glass, seen through the glass, are as perfectly continuous as those of a mercurial amalgam, and the mirror is as good. A and B form bluish-green mirrors, C gold or copper colored mirrors.

2. *The Halogen Reaction.*—When any of these allotropic forms of silver are brushed over paper and the resulting metallic films are exposed to the action of any haloid in solution, very beautiful colorations are obtained. The experiment succeeds best with substances that easily give up the halogen, such as sodium hypochlorite, ferric chloride, iodine dissolved in potassium iodide, etc. But indications are also obtained with alkaline salts, such as ammonium chloride, etc., though more slowly and less brilliantly. With sodium hypochlorite the colors are often magnificent, intense shades with metallic reflections, reminding one of the colors of a peacock's tail. Blue is the predominating tint. These are interference colors, caused by thin films, but whether of a normal silver haloid or a hemi-salt, cannot be said. When silver leaf (normal silver) is fastened to paper and a comparative trial is made, the contrast is very striking. This matter will be more particularly examined in the second part of this paper, and is mentioned here as one of the reactions distinguishing allotropic from ordinary silver.

3. *The Action of Acids.*—The stronger acids, even when much diluted, instantly convert the allotropic forms of silver into normal gray silver; even acetic acid, not too much diluted, does this. It is important to remark that this change takes place absolutely without the separation of gas. I have more than once watched the whole operation with a lens and have never seen the minutest bubble escape.

4. *Physical Condition.*—All these allotropic forms of silver are easily reduced to an impalpable powder. One is surprised to see what is apparently solid burnished metal break easily to pieces and by moderate trituration yield a fine powder.

A. Soluble Allotropic Silver.

A solution of ferrous citrate added to one of a silver salt produces instantly a deep red liquid. (Ferrous tartrate gives the same reaction, but is less advantageous.) These red solutions may either exhibit tolerable permanency or may decolorize, letting fall a black precipitate. It is not necessary to prepare the ferrous salt in an isolated form. A mixture of ferrous sulphate and sodic citrate answers perfectly.

When, however, concentrated solutions are used with a large excess of ferrous sulphate and a still larger one of alkaline citrate, the liquid turns almost completely black. It should be stirred very thoroughly for several minutes, to make sure that the whole of the precipitated silver citrate is acted upon by the iron. After standing for ten or fifteen minutes, the liquid may be decanted, and will leave a large quantity of a heavy precipitate of a fine lilac blue color. It is best to adhere closely to certain proportions. Of a ten per cent. solution of silver nitrate, 200 c. c. may be placed in a precipitating jar. In another vessel are mixed 200 c. c. of a thirty per cent. solution of pure ferrous sulphate and 280 c. c. of a forty per cent. solution of sodic citrate. (The same quantity of ferrous sulphate or of sodic citrate in a larger quantity of water will occasion much loss of the silver product.) I think some advantage is gained by neutralizing the ferrous solution, which has a strong acid reaction, with solution of sodium hydroxide: as much may be added as will not cause a permanent precipitate. To the quantities already given, add about 50 c. c. of 10 per cent. soda solution. The reaction takes place equally well without the soda, but I think the product is a little more stable with it. The mixed solution is to be added at once to the silver solution.

The beautiful lilac shade of the precipitate is rather ephemeral. It remains for some time if the precipitate is left under the mother water, but when thrown upon a filter, it is scarcely uncovered before the lilac shade disappears and the precipitate takes a deep blue color, without losing its solubility. It may be washed either on a filter or by decantation, with any saline solution in which it is insoluble and which does not affect it too much. On the whole, ammonic nitrate does best, but sodic nitrate, citrate, or sulphate may be used, or the corresponding ammonia salts. Although in pure water the precipitate instantly dissolves with an intense blood red color, the presence of five or ten per cent. of any of these salts renders it perfectly insoluble. I have usually proceeded by adding to the precipitate (after decanting the mother water as completely as may be and removing as much more as possible with a pipette) a moderate amount of water; for the above quantities about 150 c. c. Much less would dissolve the precipitate but for the salts present; this much will dissolve the greater part, but not the whole, which is not necessary. A little of a saturated solution of ammonic nitrate is to be added, just enough to effect complete precipitation.

As the material appears continually to change, the amount of washing needed must depend upon the object in view. If wanted for analysis, the washing must be repeated many times until ferric salt ceases to come away, but no amount of washing will entirely eliminate it. After seven or eight solutions in pure water and as many precipitations, the material is to be thrown on a filter, the liquid forced out as completely as possible with a pump, and then the ammonic nitrate washed out with ninety-five per cent. alcohol until the filtrate leaves nothing on evaporation. The substance at this point is still soluble in water, though much less so than at first. During the washing the solubility slowly but steadily diminishes, a fact rendered noticeable by less and less ammonic nitrate being needed to precipitate it from its solution.

Analysis.—The product, after thorough washing as above described with alcohol, was dried at ordinary temperatures or a little above, and was then reduced to very fine powder and washed again with water as long as anything dissolved. It was then dried at 100° C. in water bath. Three silver determinations were made—

A1	97·31	per cent silver.
A2	97·18	" "
B	97·21	" "

A1 and A2 were made with different portions of the same material, B with different material prepared in exactly the same way.

The substance therefore contained on an average 97·27 per cent. of silver. The nature of the residue would decide whether the material was silver with a certain amount of impurity firmly attached to it, or whether we had to do with silver in chemical combination with other elements.

The filtrate from the silver chloride in analysis A2 was evaporated to dryness and was found to contain chiefly iron and citric acid. The iron was thrown down as sulphide, redissolved in nitric acid, precipitated hot, washed with boiling water, and gave 0·8947. The residue therefore consisted of ferric oxide and citric acid, probably in the form of ferric citrate, and attached so strongly that even the very careful and prolonged washing given failed to remove them. Stronger means would be required than could be used without altering the condition of the substance. The conclusion therefore seemed to be justified that the material consisted of uncombined silver simply mixed with impurity.

To verify this conclusion by additional evidence, the substance was examined as to its behavior when heated. For if any other element were chemically combined with the silver it, would only be (in view of the high percentage of silver) hydrogen or oxygen. We might have to do with a hydride, analogous to Wurtz's hydride of copper, or possibly an oxide, but not probably, as Ag_4O would contain only 96·43 per cent. of silver.

The presence of either hydrogen or oxygen in combination with silver seems to be pretty certainly negatived by the action of dilute sulphuric acid on this (and the two other substances, B and C, to be described farther on). They are all converted into gray metallic silver without the slightest escape of gas. This seems tolerably conclusive in itself, and the result of exposing a great number of specimens of all the forms A, B, and C to the action of heat was equally so. As the object was to expose the fresh and moist material to a gradually increasing heat from that of boiling water to a low red heat without interrupting the process, the following arrangement was found convenient.

A piece of Bohemian glass tube about six inches long was sealed in the lamp at one end, the other closed with a rubber cork, through which passed a small gas delivery tube and another tube passing into a small test tube partly filled with water and having another tube through the cork passing under the surface of the water, thus preventing regurgitation. The material was thus first exposed for some hours to a heat of about 150° C. in a chloride of calcium bath; this was next removed and the heat continued to low redness. Only traces of gas were evolved, and this was found to be, in all of the many trials made, carbonic acid, derived from the citric acid adhering. This treatment was repeated many times with all the different varieties of the substance and with the same result. The temperature was always raised sufficiently high to insure the complete conversion of the material into normal gray silver, but in no case was oxygen or hydrogen set free.

It could not be overlooked that in all these trials the material had passed into an insoluble form before the silver determination was made. There remained therefore this possibility, that the silver, so long as soluble, might be in combination with citric acid, and that its change to the insoluble condition was caused by its separating from the citric acid. It seemed desirable that this view should be tested. As the object was to determine the condition of the silver in the substance as originally formed, avoiding as far as possible to change that form by attempts at purification, the only course available was to determine the ratio between the silver on the one hand and the citric acid on the other, either excluding from the determination, or else removing, that portion of the citric acid which was combined with sodium (sodic citrate being used in excess) or with iron. The first attempt was to exclude without removing it, by using Wolcott Gibbs' ingenious method of precipitating the base by hydrogen sulphide, and determining the acid thus set free in a solution originally neutral. It was ascertained by careful experiment on weighed quantities of pure anhydrous citric acid, that exact titration could be made with the aid of phenolphthalein. The silver was next redissolved and estimated as chloride. A large number of determinations were made, but the method proved unsatisfactory. It was found that portions of the same material operated upon separately gave different (even widely different) results. In fact, this very discordance was in itself a proof that no stoichiometrical combination existed between the silver and the citric acid.

The importance of the matter led me to take it up again with different means, estimating the citric acid by Creuse's method. In this method the solution, after being reduced to a small bulk, is exactly neutralized (with ammonia or acetic acid), is treated with a slight excess of barium acetate and then mixed with twice its bulk of 95 per cent. alcohol, let stand a day and filtered and washed with 65 per cent. alcohol. In igniting, a few drops of sulphuric acid convert the barium salt into sulphate, in which form the estimation is made. A preliminary trial with a weighed quantity of citric acid showed that this method gave fairly good results. I was obliged to vary the method somewhat. The precipitate of barium citrate carried down with it enough iron to render it ochery in appearance. It was, therefore, after thorough washing with 65 per cent. alcohol till every trace of barium acetate was removed, dissolved on the filter with dilute hydrochloric acid (acid 1, water 10), in which barium citrate is extremely soluble, and washed through. This was followed by still weaker acid, and finally with water. From the filtrate, sulphuric acid precipitated snow-white barium sulphate.

But this method requires that both the sulphates and the excess of sodic and ferric citrate shall first have been perfectly removed. The blue precipitate was therefore washed with dilute solution of ammonic nitrate until this was effected. The necessity for this purification was regrettable, as introducing a possibility of a change during the treatment. It was, however, indispensable that the ferrous, ferric, and sodic citrates present should be got rid of. The material after this treatment was still freely soluble in water, to a dark red solution. An examination of its absorption spectrum showed it to be still a true solution. From this solution the silver was first removed by H_2S and then the citric acid was determined in the above described way. (If the silver were thrown down by hydrochloric acid, the reliability of the citric determination would be impaired.) Next, the silver sulphide was converted into chloride and weighed. The result gave the ratio

1 gramme silver to 0·06195 gramme citric acid.

In this case washing out the sulphates, etc., was an affair of several days. The work was repeated, reducing the time as much as possible. The material was precipitated, decanted as soon as settled, thrown upon a filter pump and the funnel kept constantly full of ammonic nitrate in dilute solution by a wash bottle. By using very thick paper and a powerful pressure the entire washing was rapidly finished, so that in about six hours from first precipitation the material was

* Ber. d. ch. Ges., xx, 1458.
† Ibid., xx, 2286.

thoroughly washed, redissolved, and again filtered and placed under the action of H_2S. The result was

1 gramme silver to 0·0130 citric acid.

When these relations are reduced from weights to equivalents, they become:

No. 1, 1 equiv. citric acid to 55·63 equivs. silver.
No. 2, 1 " " 193·7 "

indicating both that the proportion of citric acid present is variable and that it is certainly not in stoichiometrical combination with the silver in the substance examined.

It has been already said that these solutions before being acted upon by H_2S were examined optically and found to be true solutions. The inference therefore seems to be very strong that there exists an allotropic form of silver freely soluble in water. This is a property so exceptional in a metal that I have admitted it with much hesitation. The principal arguments are as follows:

The content of silver in the various products was very carefully and I believe I may say quite accurately determined. It was extremely high, always above 97 per cent. As already remarked, this virtually excludes the presence of all elements except hydrogen and possibly oxygen. These elements were carefully searched for, but their presence could not be detected. To suppose that we had to do with a mixture in which some compound of silver was mixed with metallic silver was not possible, for as the whole was soluble, we should still have to admit the solubility of silver.

We have consequently to deal with a substance containing over 97 per cent. of silver, and neither hydrogen nor oxygen in combination with it, the remaining two or three per cent. fully accounted for by ferric oxide and citric acid determined as present as accidental impurity; the substance itself readily amalgamating with mercury by simple friction, nevertheless abundantly soluble in water. If I had been able to find any other explanation for these facts without admitting the solubility of silver, I should have adopted it. But none presented itself.

Whether in solution it exists as a hydrate, that is, in more intimate combination with one or more equivalents of water, cannot be said with entire certainty, but the easy amalgamation with mercury seems hardly to favor that view. No means could be found for settling the question absolutely. Certainly at 100° C. all water is expelled, but this is of course not an argument. All the water is not expelled by indefinite exposure to a vacuum over sulphuric acid. But the proportion left is very small.

The material examined was in all cases as nearly as possible the same as that originally precipitated, but absolute identity could not be obtained. The purification absolutely necessary effects some change. This is shown by the color. The freshly precipitated material dissolves to a blood red liquid, by great dilution yellowish red. The purified substance gives a darker red solution, which with dilution remains still red. Of the nature of the substances in the condition in which they were analyzed, I can speak with some positiveness, and these include a substance soluble in water and nevertheless appearing to be nearly pure silver.

The constitution of the lilac blue substance at the moment of formation and while still under its mother water is a matter of more difficulty; it could not be said with certainty that it was not in some way altered in the purification. Much time and labor were spent in endeavoring to settle this point, without entirely satisfactory results, and I am at present engaged in the search for a better method.

When this blue soluble substance, purified either by washing very moderately by ammonium nitrate or by washing with pure water, using those portions which remain undissolved after most has been carried through the filter, is brushed over paper and dries rapidly, it exhibits a very beautiful succession of colors. At the moment of applying it appears blood red, when half dry it has a splendid blue color with a lustrous metallic reflection, when quite dry this metallic effect disappears and the color is mat blue. Examined with a polarizer it shows the same characters as to two reflected beams of light polarized in planes perpendicular to each other that are described further on under B.

When the blue substance prepared in either way dries more slowly in lumps, the result is very variable; sometimes it is bright bluish metallic; sometimes dull lead color, with a metallic reflection only where it has dried against a smooth surface.

B. Insoluble Form of the Foregoing.

The solution of the blue product just described is influenced in a remarkable way by the addition of almost any neutral substance. So far I have not found any that does not precipitate it. Not only saline solutions do this, but even a solution of gum arabic.

Neutral salts may precipitate the silver in either a soluble or an insoluble form. Alkaline sulphates, nitrates and citrates throw down the soluble form, magnesium sulphate, cupric sulphate, ferrous sulphate, nickel sulphate, potassium bichromate and ferro-cyanide, barium nitrate, even silver nitrate and other salts, throw down a perfectly insoluble form. The soluble form constitutes a blue or bluish black precipitate; the insoluble, a purple brown, which by repeated washing, by decantation or otherwise, continually darkens.

What is very curious is that the insoluble form may be made to return to the soluble condition. Many substances are capable of effecting this change. Sodium borate does so, producing a brown solution, potassium and sodium sulphate produce a yellowish red solution, and ammonium sulphate a red one. None of these solutions has the same blood-red color as the original solution; the form of silver seems to change with the slightest change of condition.

The solutions used must be extremely dilute, otherwise the silver, though rendered soluble in pure water by them, will not dissolve in the solution itself—a singular complication of effects. So that if a moderately strong solution of one of the above substances is poured over the insoluble silver substance, it does not dissolve, but by pouring off the saline solution and replacing it with pure water, the substance now dissolves readily. The insoluble substance is also readily soluble in ammonia. The solution has a fine red color, and not the yellowish red of the sodium sulphate solution.

Most neutral salts act in one or other of the ways just described, precipitating the solution of the blue substance A in either the soluble or the insoluble form, the latter soluble in ammonia, but sodium nitrite is an exception; its solution effects an entire change and renders the substance wholly insoluble, probably reconverting it to normal silver.

Sometimes the substance will spontaneously pass into a soluble form. A specimen, rendered insoluble by precipitation with ferrous sulphate, after much washing began to run through, not only as a suspension, which often happens, but as a solution, clearing itself, after a day or two, of insoluble portions and furnishing a rose-red solution. I have kept this solution in a corked vial for eight months, during which time it has remained unchanged.

The general properties of this substance can be much better observed in the thin films obtained by brushing the moist substance over paper than in the lumps. The films thus obtained are bright greenish metallic, and this green evidently results from a mixture of blue and yellow, as in some lights the blue, in others the yellow, is most evident. When these films are examined by light reflected from them at a large incidence with the normal and a Nicol's prism, or an achromatized prism of calc-spar is interposed between the film and the eye, it becomes at once apparent that the blue and yellow light are oppositely polarized. The yellow light is polarized in the plane of incidence, the blue light perpendicularly to that plane. All specimens show the yellow light, but the quantity of blue light is very variable and is directly connected with the amount of washing applied to the precipitate. The more it is washed, the more the yellow predominates. To see the blue form in its full beauty, a little of the red solution may be precipitated with a very little magnesium or aluminum sulphate and be thrown on a filter. As soon as the liquid has drained off, and without any washing, the deep bronze-colored substance is to be brushed over paper. On drying it has all the appearance of a bright blue metal with a remarkable luster. The mirrors obtained by brushing the substance over glass are so beautiful and so perfect that it seems as if this property might have useful applications, especially for silvering irregular surfaces. Much care, however, would be necessary in the preparation to obtain a permanent product.

Crystallization.—On one occasion this substance was obtained in a crystalline form. Some crude red solution had been set aside in a corked vial. Some weeks after, it was noticed that the solution had become decolorized, with a crystalline deposit at bottom. The bottle was carefully broken; the deposit, examined by a lens, consisted of short black needles and thin prisms. Evidently the saline matters present had balanced the silver in solution so nearly as not to cause an immediate precipitation, but a very gradual one only. The mother water was drained off and a few drops of pure water were added. No solution took place. The crystals were therefore of the material B, the insoluble form. The contact of pure water instantly destroyed the crystallization, and the substance dried with a bright green metallic luster. Contact with pure water evidently tends always to bring this form of silver into the colloidal state, sometimes soluble and sometimes not; while the contact with certain neutral salts renders it crystalline.

The extraordinary sensitiveness which allotropic silver shows to external influences contrasts strongly with the inertness of normal (probably polymeric) metallic silver. When we place this fact alongside of the well known sensitiveness of many silver compounds to light, heat, and (as I have elsewhere shown) to mechanical force,* we are led to ask whether silver may not exist in this form in these very sensitive compounds.

To obtain the substance in a pure condition suitable for analysis, it is necessary to choose a precipitant not giving an insoluble product with either citric or sulphuric acid. Magnesium sulphate or nickel sulphate answers well; I have generally used the first named. A very dilute solution is made of it and the red solution of A is to be filtered into it. The precipitate soon subsides. A large quantity of water is to be poured on, and then washing by decantation can be continued to three decantations, after which the substance remains suspended. It can be made to subside by adding a very small quantity of magnesium sulphate; one four-thousandth part (0·25 gramme to one liter) is sufficient. The substance may then be thrown on a filter and washed with pure water.

Analysis.—A specimen dried in vacuo over sulphuric acid gave—

No. 1..... 97·17 per cent. silver.
No. 2..... 97·10 " "

A specimen dried first in vacuo and then at 100° C. lost in the second drying 0·88 per cent. water.

So that the substance dried at 100° contained 97·96 per cent. of silver. The remaining 2·04 per cent. consisted of ferric oxide and citric acid.

C. Gold-yellow and Copper-colored Silver.

It has been long known that golden-yellow specks would occasionally show themselves in silver solutions, but could not be obtained at will, and the quantity thus appearing was infinitesimal. Probably this phenomenon has often led to a supposition that silver might be transmuted into gold.† This yellow product, however, is only an allotropic form of silver, but it has all the color and brilliancy of gold, a fact which was apparent even in the minute specks hitherto obtained.

By the means presently to be described, silver can be converted wholly into this form. It is a little curious that its permanency seems to depend entirely on details in the mode of formation. I found many ways of obtaining it, but in a few months the specimens preserved changed spontaneously to normal silver. This happened even in well closed tubes. The normal silver produced in this way is exquisitely beautiful. It has a pure and perfect white color, like the finest frosted jeweler's silver, almost, in fact, exceeding the jeweler's best products. I found, however, one process by which a quite permanent result could be obtained. Specimens made by it in November of 1886 are now, at the end of thirty months, unchanged.

In forming the blue product which I have called A, very concentrated solutions were necessary. C, on the contrary, is best obtained from very dilute ones. The following proportions give good results.

Two mixtures are to be prepared: No. 1, containing 200 c. c. of a ten per cent. solution of silver nitrate, 200 c. c. of twenty per cent. solution of Rochelle salt and 800 c. c. of distilled water. No. 2, containing 107 c. c. of a thirty per cent. solution of ferrous sulphate, 200 of a twenty per cent. solution of Rochelle salt, and 800 of distilled water. The second solution (which must be mixed immediately before using only) is poured into the first with constant stirring. A powder, at first glittering red, then changing to black, falls, which on the filter has a beautiful bronze appearance. After washing it should be removed while in a pasty condition and spread over watch glasses or flat basins and allowed to dry spontaneously. It will be seen that this is a reduction of silver tartrate by ferrous tartrate. The metallic silver formed by reduction with ferrous citrate and ferrous tartrate is in an allotropic condition; with ferrous oxalate this result does not seem to be produced.

Although the gold-colored silver (into which the nitrate used is wholly converted) is very permanent when dry, it is less so when wet. In washing, the filter must be kept always full of water: this is essential. It dries into lumps exactly resembling highly polished gold, especially the surfaces that have dried in contact with glass or procelain. For this substance has in a high degree the property already described in forms A and B—that of drying with the particles in optical contact. When the thick, pasty substance is extended over glazed paper, it dries with the splendid luster of gold leaf, with this essential difference, that these allotropic forms of silver B and C assume spontaneously in drying the high degree of brilliancy which other metallic surfaces acquire by elaborate polishing and burnishing. By brushing a thick paste of this substance evenly over clean glass, beautiful gold-colored mirrors are obtained; the film seems to be entirely continuous, and the mirror is very perfect.

By continued washing the precipitate changes somewhat, so that in drying it takes on a coppery rather than a golden color, and is rather less lustrous, though still bright and permanent.

Two silver determinations by conversion into chloride, made in November, 1886, gave:

No. 1 ..... 97·81 per cent. silver.
No. 2 ..... 97·86 " "

Recently these experiments have been repeated and the washing was more successful. Ferric tartrate adheres very obstinately, and after a time washing with water ceases to remove it. Stronger means cannot be employed without affecting the substance itself. These last determinations gave:

No. 1 ..... 98·750 per cent. of silver.
No. 2 ..... 98·749 " "

The residue of No. 2 was examined, and consisted almost wholly of ferric citrate.

Chestnut Hill, Philadelphia, April, 1889.

NOTE.—The editors have received, from the author of the above paper, samples of the three allotropic forms of silver which he describes, and also strips of glass and paper coated with them. Mr. Lea is to be congratulated on his very important results. The coated strips, including the gold-colored mirror made with the "gold-silver," answer fully to his description. The mirror is remarkable for its perfection and brilliancy.—*American Journal of Science.*

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* Production of an image on silver iodide capable of development by simple pressure.

† I have a little volume published in Paris in 1857 by a chemist named Tiffereau, who was firmly convinced that in many reactions, minute portions of silver are converted into gold, especially with the aid of powerful sunlight. In Mexico, he affirmed, he had artificially produced several grammes of gold, a portion of which he presented to the French Academy with one of his papers. To his great disappointment he did not succeed in repeating these experiments in Paris, with more than an infinitesimal result. All gold, in his opinion, had been originally silver, and this belief, he affirms, is universal among Mexican miners. The book has for title "*Les Metaux sont des Corps composes.*"

PROCESS FOR HARDENING PLASTER OF PARIS.

M. JULTE, in a communication to the French Academy of Sciences, suggests a new process of hardening plaster so as to adapt it to the construction of flooring in place of wood, and to other purposes for which it cannot be used in its ordinary state on account of its want of hardness and resistance to crushing.

M. Julte recommends the intimate mixture of six parts of plaster, of good quality, with one part of finely sifted, recently slaked white lime. This mixture is employed like ordinary plaster. After it has become thoroughly dry, the object manufactured from it is saturated with a solution of any sulphate whatever whose base is precipitated in an insoluble form by lime. The sulphates best adapted for the purpose, from every point of view, are those of iron and zinc.

With sulphate of zinc, the object, at first greenish, finally assumes through desiccation the characteristic tint of sesquioxide of iron. The hardest surfaces are obtained with iron, and the resistance to breakage is twenty times greater than that of ordinary plaster. In order to obtain a maximum of hardness and tenacity, it is necessary to temper the limed plaster well in as brief a space of time as possible, and with no more water than is strictly necessary.

The plaster cast, or other object to be hardened, should be very dry, so that the solution employed may penetrate it readily. The solution should be near the point of saturation, and the first immersion should not exceed two hours. If immersed too long, the plaster would become friable.

The proportions of the lime and plaster are arbitrary, and may be varied according to the results to be obtained; nevertheless, the proportions of one to six have given the best results.

COPPER AND ZINC IN THE SUN.—Recent spectroscopic investigation by Prof. C. C. Hutchins makes it quite probable that zinc, and almost completely demonstrates that copper exists in the solar atmosphere.

THE MYSTERIOUS BALL.

AT the circus of the Champs Elysees, at Paris, a performance is now being given that would really put the sagacity of the spectators to the test did not the performer explain it after his exhibition.

A ball, 30 inches in diameter, is brought into the ring and placed on top of a sloping bridge formed of two planks with an intervening platform (Fig. 1). All at once, the ball begins to rock a little, and then moves to the edge of the platform, whence one might expect to see it roll immediately to the base of the inclined

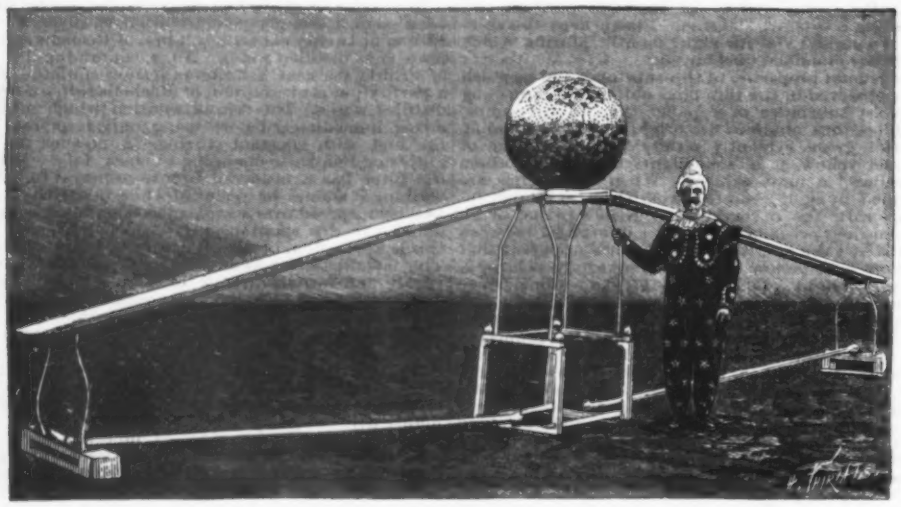

FIG. 1.—THE MYSTERIOUS BALL.

plane; but it does nothing of the sort. It stops at the edge and begins to descend with precaution. It seems to hesitate, passes over but a small space, then ascends a little, stops again, and then starts off again in fine style. When it has reached the base of the inclined plane, the lower extremity of which is about 20 inches from the ground, it stops, and then rapidly ascends to the top again. Here the mystery begins to be explained. All at once a flag is seen to make its exit through a small aperture, then a shot is fired from the interior; the ball is certainly inhabited. This we soon have proof of, for, after rolling rapidly to the base of the second inclined plane, it falls upon a cushion placed upon the ground, where a man steps forth from it. It is the clown, Lepere. It is very surprising to see a man of such a stature (5 feet) make his exit from so small a ball.

Although we have seen "India rubber men" who could place themselves in so confined a space, we cannot compare their performance to that of Mr. Lepere, who not only places himself within his ball, but moves therein with a skill that is truly wonderful. It is necessary, in fact, to have a remarkable sense of equilibrium and remarkable suppleness to be able, in such a position, to continually displace the center of gravity of the ball and keep it always in the vertical plane passing through the axis of the bridge. Fig. 2 shows how Mr. Lepere places himself. After the ball is closed, an equilibrium exists only when he is seated.

When he wishes to make his ball move forward, he must bend over and walk upon his hands and knees, after the manner of a squirrel in his wheel. But how many precautions have to be taken to make the axis of the body coincide with that of the bridge, so that the ball shall not fall from the inclined plane, which is but 12 inches wide! And what agility does it not require

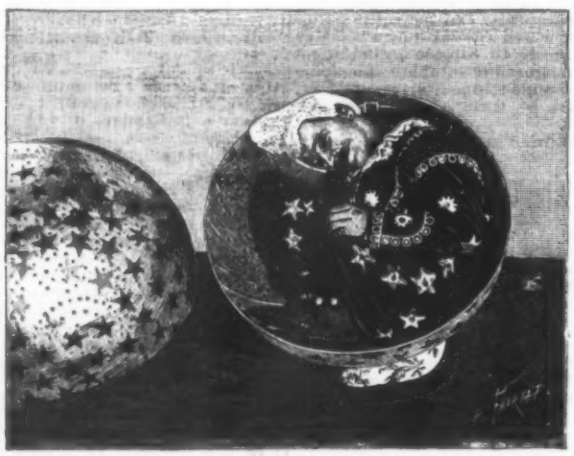

FIG. 2.—THE CLOWN IN THE MYSTERIOUS BALL.

to react immediately against the velocity acquired, after the ball, in consequence of a displacement, has begun to roll! Center of gravity, velocity, and inertia are principles of mechanics that exhibitions of strength and dexterity often put under contribution. Although clowns do not bother themselves much with learning the principles of mechanics upon which their performances are based, they apply them with wonderful dexterity.

They have a sort of instinct, a special aptitude, which permits them quickly to find the position of equilibrium. The performance that Mr. Lepere presents in so ingenious and new a fashion is an evident proof of this.—*La Nature.*

THE SQUIRREL QUESTION.

THIS question, so often answered in our notes and queries columns, seems still to cling to our readers of argumentative proclivities. We therefore place the question in a form for reference for the convenience of all comers.

In its treatment we take the relations in their mechanical and mathematical aspects and without the quibble on the words "around" or "about" so much used in the arguments presented by correspondents. In this matter we adopt the customary phraseology of our best authorities in celestial physics and dynamical engineering.

The condition of revolution of the inner body around or about which an outer body moves does not invalidate the fact of the revolution of the outer body around the inner body, nor of two bodies around each other, as is exemplified in the declarations of astronomical authorities that "the planets revolve around the sun" and "about the sun," and that the satellites move "around their planets" are characteristic of the movement of the hunter around a body within his own circle, whether the inner body is in motion or at rest.

A wheel revolves upon its axle. Its periphery revolves around every particle within its circumference, and any particular section of the periphery *goes around* the spokes, hub, and axle, or is successively on every side of their position.

The fact that a particular side of the hub is always turned toward a particular part of the periphery does not negative the general terms of the question.

The question as generally put, "Does the hunter go around the squirrel?" clearly admits of an affirmative answer.

The quibble of "on all sides of the squirrel" should properly be incorporated in the body of the question, which would make its solution as clearly a negative one.

THE WAGON WHEEL QUESTION.

THIS question comes under many forms, and the answers may be found among the following axioms of dynamics:

For a wheel rolling along a horizontal plane, its periphery revolves around its center or axle with equal velocity in all its parts. The center or axle being progressive in a line parallel with the plane or track, moves at one half the speed of the top of the wheel. The top of the wheel is not a fixed point in its periphery, but the periphery moves through a fixed point which is in a vertical line through the axis, said fixed point being the top of the wheel at all times, hence the top is said to move forward twice as fast as the axle.

Any line through the axis of the wheel with the periphery for its limit is equivalent to an equally divided lever, of which the ends have equal and opposite motions, or with a moving fulcrum. The ends also have opposite and equal motions. Then if the motion of center is one and the top two, the bottom does not move, because 1 is an arithmetical mean between 2 and 0.

From this the deduction is plainly made that the bottom of a rolling wheel does not move.

The curve swept by a fixed point in the periphery is epicycloidal, with a major axis equal to 3·1416 times the diameter, and a half minor axis equal to the diameter of the wheel. Any point within the periphery, as the crank pin of a locomotive wheel, also sweeps through an epicycular curve, having its major axis equal to 3·1416 times the diameter of the wheel, and a half minor axis equal to twice the radius of the center of the pin.

The outer end of a spoke has the swiftest motion, moving through an epicycloid due to its distance from the center and its progressive forward motion, while the motion of the hub end is also epicycloidal, having the same major axis as the outer end of the spoke, but much flatter, having its half minor axis only equal to the diameter of the hub. The time being the same for both, the flatter curve has the least velocity.

A piston connected at any point within the periphery of a rolling wheel, as of a locomotive, always has a forward motion when referred to the ground or the rail; but is reciprocal when referred to the engine, from the fact that its reciprocating center is a fixture to the frame. The retrograde motion of the piston being slower than the forward motion of the engine, it cannot move backward to an observer standing upon the ground.

THE $x+y$ PROBLEM.

OUR subscribers of mathematical turn have several times come to grief over this problem. For those having deficient facilities for advice, we submit the following solution:

$$\begin{array}{ll} x^3+y=11. & \text{Let } x+y=a \\ y^3+x=7. & \text{and } x-y=b \end{array}$$

(1) Sub. $(x^3-y^3)-(x-y)=4$. $\quad x^2-y^2=ab$. Mult.

(2) $\quad ab-b=4$

(3) $\quad ab=4+b$ multiply

$$a^3b^3=16+8b+b^3.$$

Subt. (3) × 10 $\quad 10ab=40+10b$

$$a^3b^3-10ab=-24-2b+b^3$$

Add $\quad 25=25$ to complete square.

(5) $\quad a^3b^3-10ab+25=1-2b+b^3$

Reducing $\quad ab-5=1-b$

$$ab+b=6 \quad \text{add}$$

(2) $\quad ab-b=4 \quad$ subt.

$$2ab=10 \quad 2b=2$$

$\therefore \quad ab=5 \quad b=1 \quad a=5.$

(6) $\quad x^3-y^3=ab=5$

(7) $\quad x-y=b=1$ divide 6 by 7.

$$x+y=5$$
$$x-y=1 \quad \text{add and subt.}$$
$$2x=6 \quad 2y=4$$
$$x=3 \quad y=2$$

THE WAVE LENGTH OF LIGHT AS A PRACTICABLE AND A FEASIBLE STANDARD OF LENGTH.

By Profs. A. A. MICHAELSON and E. W. MORLEY.

OUR experiments have now shown that our method of making the wave length of light of some definite refrangibility a practical standard of length is perfectly feasible. Several steps are involved.

I. We prepare a metallic bar carrying two parallel plane mirrors, whose distance is as great as that at which we can get well defined interference between two pencils of light. We have found that this distance is certainly as much as an eighth of a meter and may be a quarter of a meter.

II. The distance between the two planes is determined in terms of the yard or meter. Our apparatus for this comparison may be called the interferential comparer. We have not yet used it for the final comparisons required in our method, but we have had it in daily use for subsidiary comparisons, and have just confidence in the feasibility of making determinations of great accuracy.

III. The whole number of wave lengths, say of sodium light, contained in the distance between the two planes of our intermediate standard (I) is determined. On a standard called E we have repeated this determination by entirely different steps and by different observers; the results were, 26,502, 26,502, 26,502. The method by which we make this determination by measurements of fractions, with no enumeration of whole numbers, may be briefly described. We prepare a set of intermediate standards whose lengths are nearly as the numbers 1, 2, 4, 8, 16, etc. We compare (16) with the meter, (8) with (16), (4) with (8), etc. It is easy to get the length of each within one-fifth of a wave length. For instance, (1) = 0·4891*mm.* ± 0·0001*mm.* Now the determinations by other methods of the wave length of D show that in double this length the number of waves is 1659·1 ± 0·2 ($\lambda = 5896{\cdot}08$). We measured this fraction directly, in the refractometer previously described by us; it was 0·01 instead of 0·10; the corrected number is therefore 1659·01. With this corrected value, we found double (2) to contain 3314·22 wave lengths; and correcting the fraction, 3314·27. In this way we have gone in triplicate, with five different kinds of light, to numbers ranging for these different kinds of light, but for the same intermediate standard between 23,270 and 35,815; and in duplicate to numbers four times as large for four kinds of light.

IV. The measurement of fractions mentioned above may be made in various ways. We have often made it consist in measuring the diameter of circular interference fringes by means of the filar micrometer. In this way it is not difficult to make determinations trustworthy to $\frac{1}{10}\lambda$, as far as *optical* errors are concerned. Sometimes we make it consist in shortening the effective path of one of the interfering rays by a minute of angular motion of a certain part of the apparatus, and

measuring this motion by the torsional couple required to produce it. This method we find capable of almost incredible precision.

V. As a somewhat tangible evidence of the feasibility of our method, we may use our data for the inverse problem of determining wave lengths. The results of two entirely independent series of determinations by one of us, and of one by the other, are as follows:

	Na.	Li.	Hg_γ	Hg_β	Hg_ν
I	5896·08	6707·98	5790·70	5460·85	4358·43
II	5896·08	6708·00	5790·67	5460·85	4358·42
III	5896·09	6708·00	5790·68	5460·85	4358·41
Mean	5896·083	6707·993	5790·683	5460·850	4358·417

VI. We feel a reasonable confidence that the number of wave lengths in (16) is known to one part in a million as a result of our early experience with apparatus devised in a tentative way. We feel a reasonable confidence that this distance may be made eightfold or sixteenfold longer, with a proportionate increase in precision. We think we have the right to hope that with better apparatus, and with the benefit of the experience already gained, the work of establishing a material standard a meter in length whose length in wave lengths is known to a millionth or even a ten-millionth may be effected with ease and certainty.

In regard to the relative motion of the earth and the luminiferous ether, I have only to say that the observations of July were repeated in November and December, with the result that if any relative motion between the earth and the luminiferous ether can be detected by such experiments its amount is less than one-sixth of the absolute motion of the earth.

Cleveland May 13, 1889.

—*Sidereal Messenger.*

BAMBANGALA.

THE curious antelope called *Bambangala* is spoken of by Captain Bateman in his "The First Ascent of the Kasai," lately published by Messrs. George Philip & Son. Captain Bateman describes it as being "in size as large as a mule; of a bright chestnut color, striped with creamy white, much in the manner of a zebra, on the back and sides, and dappled on the neck and flanks."

From the form of the horns shown in the figure (which by the kind permission of Messrs. George Philip & Son is here reproduced from Captain Batemen's book), it would appear that this antelope must belong to the genus *Tragelaphus*, but probably to a new species.—*Nature.*

[GARDEN AND FOREST.]

NOTES ON THE PRODUCTION OF MAPLE SUGAR.

ONE of the most important and interesting of the early writings on the sugar maple is "An Account of the Sugar Maple Tree of the United States," by Dr. Benjamin Rush. It was written in the form of a letter to Thomas Jefferson, was read before the American Philosophical Society and published in the "Transactions" of the Society in 1792. Some of the statements hold good at this time, but others sound oddly when compared with modern knowledge and practice. Dr. Rush had a very high opinion of the merits and value of the sugar maple. He says: "Its small branches are so much impregnated with sugar as to afford support to the cattle, horses, and sheep of the first settlers during the winter, before they are able to cultivate forage for that purpose. . . . The tree is supposed to arrive at its full growth in the woods in twenty years. . . . It is in consequence of the sap of these trees being equally diffused through every part of them, that they live three years after they are *girdled*—that is, after a circular incision is made through the bark into the substance of the tree for the purpose of destroying it." We are told that there are three methods of reducing the sap to sugar: "By freezing it," "by spontaneous evaporation," and "by boiling." After giving some figures to show that more sugar might be made from the maple in the country than would be necessary for home consumption, Dr. Rush, in speaking of the benefits he expects from its general use, says: "They will, I hope, extend themselves to the interests of humanity in the West Indies. With this view of the subject of this letter, I cannot help contemplating a sugar maple tree with a species of affection and even veneration, for I have persuaded myself to behold in it the happy means of rendering the commerce and slavery of our African brethren in the sugar islands as unnecessary as it has always been inhuman and unjust." In a foot-note we are told that "Mr. Jefferson uses no other sugar in his family than that which is obtained from the sugar maple tree. He has lately planted an orchard of maple trees on his farm in Virginia."

Since Dr. Rush wrote his paper much progress has been made in the production and manufacture of sirup and sugar from the maple, although it has not received so much attention as has fruit growing and some other kindred industries. It is a most important source of income on many of our Northern farms, and the sugar orchard, or "sugar bush," as it is often called, is in many districts coming to be as well looked after and cared for as a vineyard or fruit orchard. The annual profit is probably larger than the average of farm crops occupying the same acreage of ground, and the work is done before the ordinary farm labors have begun. In many well-managed sugar orchards the dead and diseased branches are carefully pruned off, and the wounds covered by some protecting substance to prevent injuries by insects or fungus diseases.

Some of the more thrifty proprietors, at the end of the sap harvest, have the holes which were bored in the trees carefully plugged with neat stoppers of dry, sound wood, cut so as not to project beyond the surface of the last ring of wood formed. At the close of the growing season the new layer of wood and bark will have completely covered the wound. This is a great improvement on the barbarous method of making a great gash in the side of the tree with an ax and using a chip for a spout. The amount of abuse which a large tree will bear when standing in the forest is surprising. In some districts there are many large old trees to be found having the trunks for five or six feet from the ground very rough and uneven, and often a foot greater in diameter than the trunk immediately above, caused by the earlier crude way of obtaining the sap. These trees may have been subjected to such rude treatment almost every year for half a century or more, and now, tapped in the more approved way, they continue to produce abundantly without showing other signs of injury or decay than such as are found in trees under natural conditions as they attain old age.

In regard to the manner of tapping the trees, writers still seem to differ in their accounts as to the depths bored. Dr. Rush, in the essay already quoted, says: "The perforation is made with an ax or an auger. The latter is preferred from experience of its advantages. The auger is introduced about three-quarters of an inch, and in an ascending direction, and is afterward deepened gradually to the extent of two inches."

In Emerson's "Trees and Shrubs of Massachusetts" (p. 564) it is stated that the holes are bored "to the depth of from two to six inches, according to the size of the tree," and M. Ed. Andre, in an article in the *Revue Horticole* for 1886, p. 284, says that the holes are often bored to the heart of the tree. There are probably very few experienced men, owning sugar orchards now, who have the holes bored more than a couple of inches in depth, and one inch is deemed quite sufficient by many. There is little to be gained, and a much greater possibility of injury to the tree, by boring deeply into its trunk. Probably nearly all of the sugar-bearing sap comes from the outer layer of wood, extending less than an inch deep. Many writers have stated that the south side of the tree gave the best flow of sap, but experienced men advise tapping the side bearing the most branches.

As yet most of the sugar orchards are made up of trees of natural growth, and comparatively few plantations have been set out for sugar-making purposes. The twenty-five years required by the trees to grow before being regularly tapped seems a long period to many, but if properly planted with other trees among them, the maple orchard could be made self-supporting, by annual thinning of wood, after the first few years. Trees on rocky hillsides yield more profitable sap than those on low ground, so that some of the best locations would be on New England hillsides that

THE BAMBANGALA.

are now bare and unprofitable. The French Canadians in some portions of Canada are said to be planting large quantities of the ash-leaved maple (*Negundo aceroides*), with the idea of producing sirup and sugar from it, and because it is a fast-growing tree.

The time may not be far distant when nurserymen will give particular attention to the propagation of the best sugar-producing strains of maples and other native trees. Careful comparative studies of the amount of sap obtained from different species of trees, and of the same species under different conditions, and of the percentages of sugar contained in the sap, are much needed. Numerous analyses have been made of saps by different investigators, but the published results are very contradictory and unsatisfactory. While, no doubt, much depends upon the surroundings, vigor, and other conditions attending the trees, it seems as if some general rules might be determined upon which would be approximately reliable. Dr. G. L. Goodale gives the average amount of sugar in the sap of *Acer saccharinum* as about eight per cent. (Physiological Botany, p. 360), which seems very high when compared with the results of other experiments. In the report of the Massachusetts Board of Agriculture, 1874-75 (p. 290) the analysis by Charles Wellington gave a result of 2·777 per cent.

In recording some interesting experiments made in Indiana (Proceedings A.A.A.S., 1879, vol.—xxvii., p. 234) Dr. H. W. Wiley gives the highest percentage as 4·30, from a tree noted for the sweetness of its sap. In a series of experiments conducted at Lunenburg, Vermont, under the direction of Dr. Wiley, and published in Bulletin No. 5 (1885) of the Chemical Division of the Department of Agriculture, the highest percentage recorded was 10·20 in a small flow of sap from a specimen of sugar maple during one of the last days of the flow, the average being 5·01 per cent., and 9·88 per cent. was obtained from a similar flow of sap from an isolated white maple (*Acer dasycarpum*), which averaged 4·36 per cent. of sugar during the season. The average of all the analyses from all the trees experimented upon is considerably less than 4 per cent. of sugar.

In making some experiments on the sap of the ash-leaved maple (*Negundo aceroides*), Dr. B. J. Harrington, of McGill College, Montreal, found in a series of careful experiments that the average amount of sugar in the sap of these trees was very nearly 2·50 per cent. In a slight test of the sap from a tree of *Acer saccharinum* on the college grounds he found a little over 5 per cent. of sugar. The detailed account of the experiments with the Negundo sap is published in the "Transactions of the Royal Society of Canada," vol. v., sec. iii., 1887.

Adulterations and imitations of both sugar and sirup are very common. An extract obtained from the bark of hickory (*Carya*) is said to resemble the maple flavor very closely when mixed with cane sirups. Such imitations may tend to lower the price of the pure product a little, but there will always be a demand for the true article. It is not likely that maple will take the place of cane sugar, as Dr. Rush hoped, but the consumption and perfection of production will continue to advance.

J. G. JACK.

Arnold Arboretum.

PREVENTION OF CONSUMPTION.

DRS. PRUDDEN, Biggs, and Loomis, pathologists to the Board of Health of the city of New York, having been requested to formulate a brief and comprehensive statement regarding the contagiousness of tuberculosis and the means of protection therefrom, have submitted the following:

The disease known as tuberculosis, and, when affecting the lungs, as pulmonary tuberculosis (consumption), is very common in the human being, and in certain of the domestic animals, especially cattle. About one-fourth of all deaths occurring in the human being during adult life are caused by it, and nearly one half of the entire population at some time in life acquires it. The disease is the same in nature in animals and in man, and has the same cause.

It has been proved beyond a doubt that a living germ, called the "tubercle bacillus," is the cause, and the only cause, of tuberculosis. It does not seem necessary to state the facts upon which this assertion is based, for the observation first made by Robert Koch in 1882 has been confirmed so often and so completely that it now constitutes one of the most absolutely demonstrated facts in medicine.

Tuberculosis may affect any organ of the body, but most frequently first involves the lungs. When the living germs find their way into the body, they multiply there, if favorable conditions for their growth exist, and produce small, new growths or nodules (tubercles), which tend to soften. The discharges from these softened tubercles, containing the living germs, are thrown off from the body. In pulmonary tuberculosis these discharges constitute, in part, the expectoration. The germs thus thrown off do not grow outside the living human or animal body, except under artificial conditions, although they may retain their vitality and virulence for long periods of time, even when thoroughly dried. As tuberculosis can only result from the action of these germs, it follows, from what has just been said, that, when the disease is acquired, it must result from receiving into the body the living germs that have come from some other human being or animal affected with the disease.

It has been abundantly established that the disease may be transmitted by meat or milk from the tubercular animal. The milk glands in milch cows often become affected with the disease when their lungs are involved, and the milk from such animals may contain the living germs, and is capable of producing the disease. Among stall-fed dairy cows, 20 per cent. or 30 per cent. are sometimes found to be affected with the disease. Tubercular animals are also frequently killed for food, their flesh sometimes containing the germs, and, if not thoroughly cooked, it is capable of transmitting the disease. Boiling the milk, or thoroughly cooking the meat, destroys the germs. Although the meat and milk from tubercular animals constitute actual and important sources of danger, the disease is acquired, as a rule, through its communication from man to man.

Tuberculosis is commonly produced in the lungs (which are the organs most frequently affected) by breathing air in which the living germs are suspended as dust. The material which is coughed up, sometimes in large quantities, by persons suffering from consumption, contains these germs, often in enormous numbers. This material, when expectorated, frequently lodges in places where it afterward dries, as on the streets, floors, carpets, clothing, handkerchiefs, etc. After drying, in one way or another, it is very apt to become pulverized, and float in the air as dust.

It has been shown experimentally that dust collected from the most varied points in hospital wards, asylums, prisons, private houses, etc., where consumptive patients are present, is capable of producing tuberculosis in animals when used for their inoculation. Such dust may retain for weeks its power of producing the disease. On the other hand, dust collected from rooms in institutions or houses that have not been occupied by tubercular patients does not produce the disease when used for the inoculation of animals.

These observations show that, where there are cases of pulmonary tuberculosis, under ordinary conditions, the dust surrounding them often contains the "tubercle bacilli," and persons inhaling the air in which this dust is suspended may be taking in the living germs. It should, however, be distinctly understood that the breath of tubercular patients, and the moist sputum, received in proper cups, are not elements of danger, but only the dried and pulverized sputum. The breath and moist sputum are free from danger, because the germs are not dislodged from moist surfaces by currents of air. If all discharges were destroyed at the time of exit from the body, the greatest danger of communication from man to man would be removed.

It then follows, from what has been said, that tuberculosis is a distinctly preventable disease. It is a well-known fact that some persons, and especially the members of certain families, are particularly liable to tuberculosis; and this liability can be transmitted from parents to children. So marked and so frequent is this liability, and so frequent is the development of the disease in particular families, that the affection has long been considered hereditary. We now know that tuberculosis can only be caused by the entrance of the germ into the body, and that this transmitted liability simply renders the individual a more easy prey to the living germs when once they have gained entrance.

The frequent occurrence of several cases of pulmonary tuberculosis in a family is, then, to be explained, not on the supposition that the disease itself has been inherited, but that it has been produced after birth by transmission directly from some affected individual. Where the parents are affected with tuberculosis, the children, from the earliest moments of life, are exposed to the disease under the most favorable conditions for its transmission; for not only is the dust of the house likely to contain the bacilli, but the rela-

tionship also between parents and children, especially between the mother and child, is of that close and intimate nature especially favorable for the transmission by direct contact.

If, then, tuberculosis is not inherited, the question of prevention resolves itself principally into the avoidance of tubercular meat and milk and the destruction of the discharges, especially the sputum of tubercular individuals. As to the first means of communication, those measures of prevention alone answer the requirements which embrace the governmental inspection of dairy cows and of animals slaughtered for food, and the rigid exclusion and destruction of all those found to be tubercular.

For the removal of the second means of communication, *i. e.*, the sputum of tubercular individuals, the problem is simple when the patients are confined to their rooms or houses. Then, wooden or pasteboard cups, with covers, should always be at hand for the reception of the sputum. These cups are supported in simple racks, and at least once daily, or more frequently if necessary, should be removed from the racks and thrown with their contents into the fire. A cheap and efficient cup answering this purpose is now on the market, and is supplied by the druggists.

The disposition of the expectoration of persons who are not confined to their rooms or homes is a far more difficult problem. The expectoration certainly should not be discharged on the street, and the only practicable means for its collection seems to be in handkerchiefs, which, when soiled, should at the earliest possible moment be soaked in a solution of five per cent. carbolic acid, and then boiled and washed. Handkerchiefs thus soiled are exceedingly dangerous factors in distributing tubercle bacilli; for, when the sputum becomes dry, it is easily separated in flakes from the cloth, and then soon becomes pulverized and suspended as dust.

It becomes evident from what has been said that the means which will most certainly prevent the spread of this disease from one individual to another are those of scrupulous cleanliness regarding the sputum. These means lie largely within the power of the affected individual. It is furthermore to be remembered that consumption is not always, as was formerly supposed, a fatal disease, but that it is in very many cases a distinctly curable affection.

An individual who is well on the road to recovery may, if he does not with the greatest care destroy his sputum, diminish greatly his chances of recovery by self-inoculation.

While the greatest danger of the spread of this disease from the sick to the well is in private houses and in hospitals, yet, if this danger is thoroughly appreciated, it is, for the most part, quite under control through the immediate destruction of the sputum and the enforcement of habits of cleanliness. But in places of public assembly, such as churches and theaters, particularly the latter, conditions are different, and the safety would seem to depend largely upon a dilution and partial removal of the floating and possibly dangerous dust by means of adequate ventilation.

Rooms in private houses and hospital wards that are occupied by phthisical patients should from time to time be thoroughly cleaned and disinfected, and this should always be done after they are vacated, before they are again occupied by other individuals. Steamship companies should be obliged to furnish separate apartments for consumptive persons, so that no person in the exigences of travel need be forced to share his room with one who might be a source of active danger to him.

Drs. Prudden, Biggs, and Loomis desire especially to emphasize the following facts: (1) that tuberculosis is a distinctly preventable disease; (2) that it is not directly inherited; and (3) that it is acquired by the direct transmission of the tubercle bacilli from the sick to the healthy, usually by means of the dried and pulverized sputum floating as dust in the air.

The measures, then, which are suggested for the prevention of the spread of tuberculosis are (1) the security of the public against tubercular meat and milk, attained by a system of rigid official inspection of cattle; (2) the dissemination among the people of the knowledge that every tubercular person may be a source of actual danger to his associates if the discharges from the lungs are not immediately destroyed or rendered harmless; and (3) the careful disinfection of rooms and hospital wards that are occupied or have been occupied by phthisical patients.

THE VOLTAIC CURRENT OBTAINED WITH BISMUTH IN A MAGNETIC FIELD.

THE following experiments are due to Dr. G. P. Grimaldi. A wide U tube contained a solution of bismuth chloride in hydrochloric acid. In the two limbs of the tube dipped two wires of chemically pure bismuth very carefully polished. One limb of the tube was placed between the conical pole pieces of a Faraday electro-magnet of medium size in such a way that the surface of the liquid was in the most intense part of the field. The two wires were joined up to a very sensitive Thomson astatic galvanometer. On closing the galvanometer circuit, a current was observed which at first varied rapidly, but which finally reached a permanent value. This was compensated by means of a shunt containing a standard element, and the galvanometer was brought back to zero.

If then the electro-magnet was excited by a powerful current, a permanent deflection of the galvanometer was observed; if the magnetizing current was broken, the galvanometer returned to zero. The current produced by magnetism, which the author calls the galvano-magnetic current, is independent of the intensity and direction of the current first observed in closing the galvanometer circuit before the magnet circuit is made. The latter is variable; the former is always in the same direction—in the galvanometer circuit, from the magnetized bismuth wire to the non-magnetized one; and in the liquid from the non-magnetic metal to the magnetic one.

The intensity of the galvano-magnetic current depends on the state of the surface of the metal, and to get regular results it is necessary to carefully polish the bismuth wires. To give an idea of the magnitude of the electromotive force of the galvano-magnetic current, the author states that in the various experiments hitherto made under good conditions with various wires, and in various modifications, it has varied from $\frac{1}{1000}$ to $\frac{1}{100}$ of a Daniell cell, the magnetic field being produced by a Faraday magnet of ordinary size, excited by a current of eight to twelve amperes, and with conical poles seven millimeters apart. With less powerful magnetizing currents, the results are smaller; and, with a current of two amperes, the galvano-magnetic current is scarcely appreciable. The direction of the galvano-magnetic current is independent of the direction of the field: its intensity sometimes varied a little when the field was reversed, and sometimes remained constant.

COMPOSITION OF A BRICK FROM THE BRICK YARD OF S. P. CRAFTS, AT QUINNIPIAC, THREE MILES NORTH OF NEW HAVEN, CONN.

By O. H. DRAKE.

THE brick clay used for making the bricks is from the bed of stratified drift in which were found bones of the reindeer, mentioned in volume x. (1875) of this *Journal*. The brick was one of the overbaked kind, much distorted, and highly vesicular or scoria like, and the texture within indicated complete fusion. The clay had been mixed with coal dust before the heating, as now usual at brick yards. The analysis of the vesicular semi-glassy portion afforded

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O
65·80	18·98	2·07	1·32	0·22	2·29	2·56	3·15	2·96=100·32.

The large percentage of potash and soda shows that the clay contained much undecomposed feldspar, which is natural in view of the fact that the crystalline rocks that were its source border the Connecticut valley through its whole distance to New Haven. The vesiculation is supposed to be due to the coal dust.—*Amer. Jour.*

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